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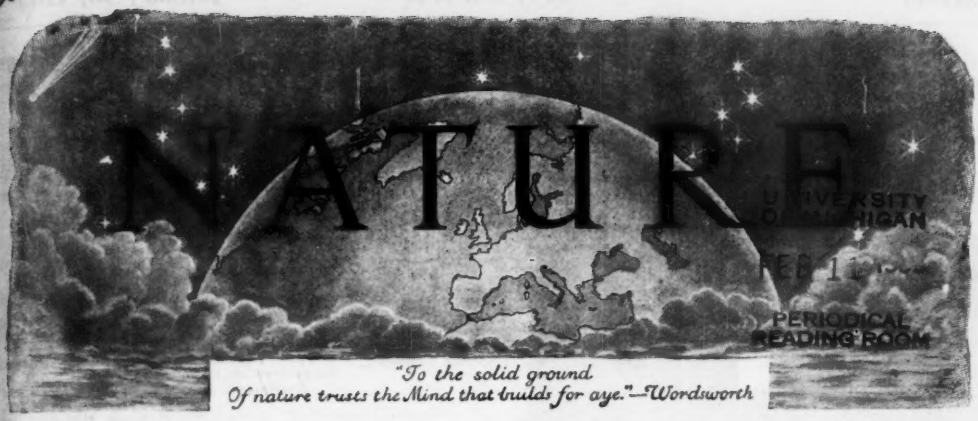

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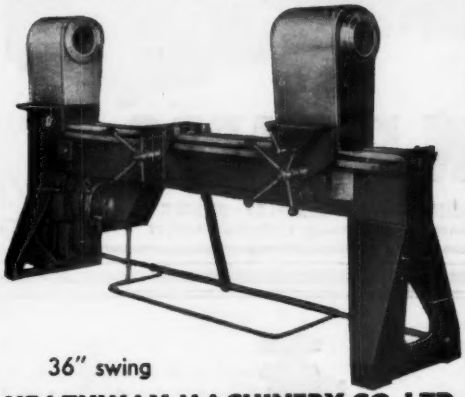

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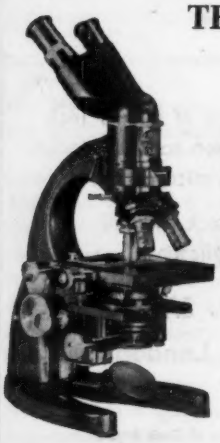

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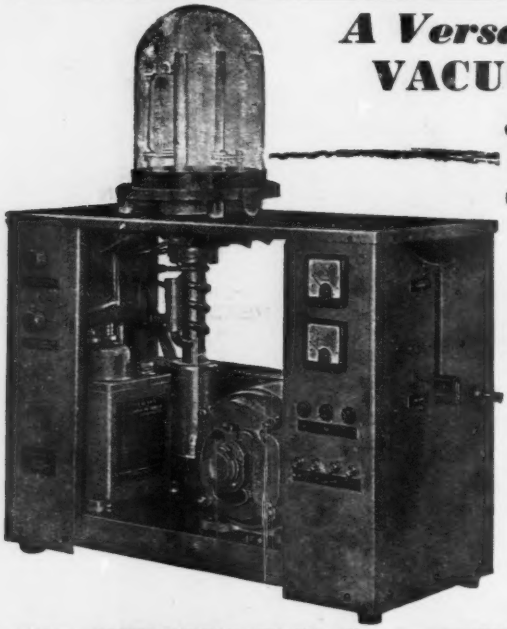

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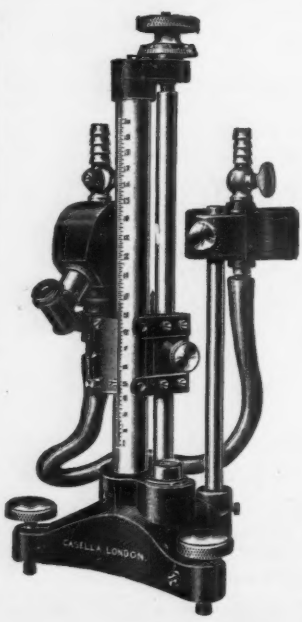

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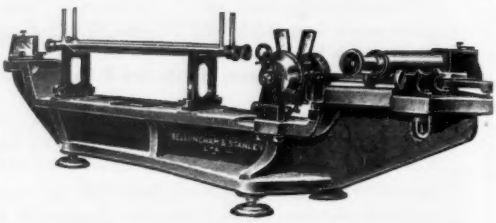

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SUPPLY OF SCIENCE TEACHERS IN BRITAIN

ATTENTION has been focused on the continuing shortage of science teachers in Britain by the reports of the Federation of British Industries and of the Advisory Council on Scientific Policy, by a resolution at the annual meeting of the Trades Union Congress and by a discussion at the Conference of the Universities of Great Britain and Northern Ireland held in London during December 17 and 18. Naturally, the subject has also been discussed during the recent meetings of educational bodies. The term 'science teachers' refers to teachers of science or mathematics in public schools, grammar schools or other schools with a significant number of sixth-form pupils. It is now accepted that there is a shortage of science teachers, that their quality is lower than it was before the War, and that the shortage is a matter of national concern because it threatens the supply of science students to the universities and so the supply of scientists to industry—and hence the standard of life of the whole community. It is also clear that the shortage will continue for some decades, unless prompt measures are taken, because of the growing demand of industry and the Scientific Civil Service for more scientists and technologists.

The situation demands two things: first, prompt measures to alleviate the present situation; secondly, an analysis of the fundamental causes of the shortage and the reluctance so far shown to take steps to end it, so that long-term remedies can be applied to secure for the schools a full supply of science teachers of good quality, which must be done before the greatly increased supply of scientists needed by the community will be forthcoming. The reports of both the Advisory Council on Scientific Policy and the Federation of British Industries rightly stress that the only permanent solution for the shortage of science teachers is the production of more science graduates; but they fail to emphasize that more science graduates cannot be produced until the shortage of science teachers has been made good.

A number of minor suggestions for immediate action to alleviate the present shortage were made in the report of the Federation of British Industries, and also by speakers at the Universities Conference. Many of them have been common practice for the past five years in schools—at best they are merely palliatives. They cannot of themselves reverse the trend which has set up the present deflationary spiral of fewer science teachers leading to fewer science graduates, producing still fewer science teachers and so on. But there are two immediate steps which, if taken, might materially reduce the present shortage of science teachers—they might even reverse the deflationary spiral. Scientists are in short supply; during the Second World War, articles in short supply were rationed. Something similar might now be attempted for scientists. A high-level conference of the interests using scientists—the Scientific Civil Service, industry, the universities and the schools—should be called to try to secure a fairer distribution of scientists. Direction of labour is clearly out of the question; but, when industry and the Scientific Civil Service know the facts, they might be ready to help themselves in the long run by decreasing their demands for scientists for a time, and so help the schools to get more science teachers now. This suggestion was the leading recommendation of the report issued in November 1953 of the National Advisory Council for the Supply and Training of Teachers; but no action was taken. The Minister of Education ought to have taken the initiative, and that no such conference has taken place suggests lack of courage and faith in the grammar schools; it is the task of the present Minister to convince his colleagues in the Government that the grammar schools hold the key to the solution of the problem of the shortage of scientists. The Advisory Council on Scientific Policy would then be a suitable body to which this fairer distribution of scientists could be immediately referred.

An apt analogy was recently given by Dr. A. W. Barton, headmaster of the City of London School. After the War, Britain was short of coal, its most precious and most abundant raw material, because there were not enough miners; so coal mining was made a form of national service, and this has had some effect in attracting more men to the mines and increasing production. We are now short of a precious human commodity, science teachers; therefore, the possibility of recognizing teaching as a form of national service should be considered. This would increase the number of science teachers coming into the schools in the year it was introduced from six hundred to nine hundred, because men teachers coming into the schools at the end of their national service would be joined by an equal number who had just graduated and would just have been starting national service in the Armed Forces. It might also do something towards a permanent solution of the problem by attracting some new men into teaching, some of whom would like it and would stay on. The compromise on national service proposed in the report of the Federation of British Industries is satisfactory neither to the Armed Forces nor to the schools. The Armed Forces can make no use of men who are to have only the six months or so needed to complete their basic training. The compromise is unfair to the schools because it fails to do justice to the serious shortage of science teachers and their present importance to the country.

The fundamental cause of the present shortage of scientists in general and science teachers in particular is the policy of full employment and the great increase in the demand for scientists since the War. Two other factors in the shortage of science teachers in particular are the exaggeration of the importance and satisfaction of research, and the decline in the prestige and financial rewards of science teaching. The steps needed to reverse the deflationary spiral and abolish the shortage of scientists would therefore seem to be fairly clear. The pre-war economic pressure due to unemployment, which provided that a sufficient number of science graduates should be available for teach-

ing, disappeared when Britain adopted a policy of full employment, and science graduates must now be induced to go into teaching by pointing out to them the importance of the work and by suggesting to them that it is the duty of those with the right qualities to take up teaching. Much might be done to this effect by arranging an annual visit to the pure science departments of each university by a headmaster or assistant master, during which third-year undergraduates and research students could be told by practising schoolmasters about the responsibilities, opportunities and rewards (financial and spiritual) of science teaching; such talks would also have to make clear the importance of science teaching in the national life. The staffs of the universities could perhaps do more, through their considerable influence with undergraduates, to persuade them to consider teaching as a career; the help of the university appointments boards and the Youth Employment Service should also be sought.

The schools themselves can help in a number of ways. Headmasters should take care, so far as their authority permits, to give their staffs good working conditions inside the schools. They could use their influence to try to persuade more pupils to stay on in the sixth form; they could stress the urgent national need for scientists when advising pupils on their choice of sixth-form studies; they could put the claims of teaching fairly before their pupils when advising them about careers. Finally, boys and girls are influenced more by what their teachers are than by what they say. If science teachers are keen, competent and devoted to their pupils, that in itself will induce in young people a respect for teaching as a profession and will result in more of them taking it up. Local education authorities can help by giving to the grammar and other secondary schools the freedom and prestige which the grammar schools enjoyed before the War and have since lost, and by ensuring that science teachers are not passed by when headships are under consideration.

There is no question that research attracts many graduates. This is due partly to the spectacular achievements in recent years both of the physical and the biological sciences, which have led graduates to believe that this is the chief road to fame. But they have often heard only about the successes; they fail to realize that these results often involve thousands of graduates and technicians, and they do not appreciate that research, like teaching and any job which is worth while, has its monotony, its failures, and perhaps more than its fair share of bewilderment and frustration. Some of the responsibility for the powerful attraction of research, however, is due to failure to maintain a proper balance in the universities between their two functions, teaching and research. It has been suggested that too many of the teaching posts in universities are filled by men interested primarily in research. The universities should re-examine the relative importance of teaching and research, of transmitting accepted truth to the next generation and of finding new truth. If they fail in the first function, must not the second of necessity wither away? When the universities have ensured that there is in each science department one man, of the status of a reader or occasionally a professor, who holds his important post because he is a distinguished teacher of his subject, then a higher proportion of undergraduates is likely to take up science teaching.

We shall only get enough science teachers in this age of full employment if we set out to produce young men and women with the right qualities, namely, an interest in science and an equally great interest in persons. One step which the universities could take to produce young men and women likely to make good science teachers would be to devise general honours degree courses in which arts and science subjects could be combined. While there is no evidence that there is undue specialization in science in the schools (indeed, in most schools all pupils spend two-thirds of their time on the humanities until they reach the sixth form and begin to specialize), they must also help in this respect by providing stimulating courses in the humanities for their science specialists, and using their influence to see that their pupils take this part of their curriculum seriously.

Finally, headmasters in schools and professors in universities cannot in honesty tell their pupils how important science teaching is and appeal to the sense of duty of those suitably qualified to take it up, unless they can also assure them of reasonable financial reward. Before the War, a science teacher had the same salary as a university lecturer, and a senior science master the same as a reader or senior lecturer. To-day the university lecturer rises to £1,350, whereas a science teacher rises to £950 under a generous local authority; the senior lecturer rises to £1,600, while a senior science master rises to £1,200 with a very generous local authority or to £950 under a niggardly one. The science teacher is clearly underpaid to-day. When the Education Act was passed in 1944, it was decided that all children were to have a proper secondary education, which implies that all secondary schools should have classes of reasonable size, buildings with comparable amenities and teachers paid on a common salary scale. This has meant that the salaries of the teachers in all types of school—primary, secondary modern and secondary grammar—are settled by a Burnham Committee in which grammar school teachers are very much in a minority. This has produced the expected effect on the salaries of teachers; the pay of the average worker has been increased at the expense of the fewer highly skilled workers, and the highly skilled minority feels that it is being unjustly treated. The Burnham Committee has been trying to work out a suitable salary scale for all teachers in the State schools for ten years; it has failed to do justice to the teachers in the grammar schools, which, from the point of view of progress and development, are the most important schools to the community, and it is clear that the Burnham Committee as at present constituted is very unlikely to solve this problem. The Minister of Education has just asked them to decide if the salaries now being paid to grammar school staffs are good enough to attract dis-

tinguished teachers. Unless the Minister's lead induces the Burnham Committee to award a substantial increase in grammar school salaries, a Royal Commission to consider the salaries of teachers in grammar schools and the problem of their recruitment appears to be desirable. This question of salary is not the only factor to be considered, but it seems fairly certain that the present shortage of science teachers is unlikely to be overcome until more attractive salaries are offered.

LECTURES BY SIR HENRY DALE

An Autumn Gleaning

Occasional Lectures and Addresses. By Sir Henry H. Dale. Pp. x+225. (London: Pergamon Press, Ltd., 1954.) 21*s*. net.

IN 1953 the Pergamon Press published a collection of famous original papers by Sir Henry Dale under the title "Adventures in Physiology" (see *Nature*, **172**, 825; 1953). The same publishers have now persuaded Sir Henry to prepare a smaller book with a more general appeal containing thirteen lectures and addresses mostly delivered during the past ten years, and extracts from five war-time presidential addresses to the Royal Society.

This book contains a mixed bag of good reading-matter written with easy and explicit fluency, and intelligible without specialized knowledge. There is an account of the history of work on viruses up to 1935. The discovery of insulin is described with the authority of one who was in direct contact with the original work and yet able to be impartial. The case for the freedom of science and the case for the inclusion of some knowledge of science as an essential part of a liberal education are put with convincing clarity and force. There are two addresses to young men on "Experiment in Medicine" and on "Medical Research as an Aim in Life". The popular lecture on "Accident and Opportunism in Medical Research", delivered in Cambridge at the annual meeting of the British Medical Association in 1948, is particularly valuable since it contains interesting details, not given in the original publications, of how great discoveries have been made. It is good to see in print the stories of the discovery of Ringer's solution through the laziness of a technician and of Dr. Oliver's injections of adrenal extracts in his son.

The book also contains addresses in honour of William Whitla, Thomas Addison and Lord Rutherford and the lecture given in connexion with the Festival of Britain reviewing a hundred years of medical progress. The last two lectures are up-to-date reviews of a more technical kind dealing with two topics on which the author is the chief authority —the mechanism of anaphylaxis, and the transmission of effects from nerve endings.

After an active life spent in leading the advance beyond the frontiers of knowledge in various specialized fields, Sir Henry has had the time between the ages of seventy and eighty years to turn his mind to problems of more general importance. He has considered the place of science in the modern world and its effects on mankind; he has important things to say on these matters and the power to say them effectively. This book is an anthology of his unmistakable and characteristic English prose and can be recommended to all who are interested in medical and allied scientific research. J. H. GADDUM

FLOW PROPERTIES OF DISPERSE SYSTEMS

Flow Properties of Disperse Systems

Edited by Prof. J. J. Hermens. (Deformation and Flow: Monographs on the Rheological Behaviour of Natural and Synthetic Products.) Pp. xi+445+12 plates. (Amsterdam: North-Holland Publishing Company; New York: Interscience Publishers, Inc., 1953.) 35 florins; 70*s*.

THIS volume is one of a series of monographs describing the rheological behaviour of natural and synthetic products. The particular disperse systems with which it deals are those containing 'large' particles well beyond ordinary molecular size, but sufficiently small to exhibit, in some instances, marked Brownian motion; it is assumed that the laws of hydrodynamics of continuous fluids are applicable to such systems provided the particles have dimensions of the order of ten times the molecular dimensions of the dispersion medium.

The ten chapters into which the book is divided treat of suspensions, emulsions, gels, dilute solutions of impenetrable rigid particles and flexible chain molecules, liquid sprays, atomization of liquids, foams, smoke and powders. The field covered is therefore wide and diverse, and the various authors have had to select, from a considerable literature, those aspects which they regard as of particular significance in the development of their subject. This limitation results in some lack of balance and some obvious omissions which are, however, in part made good by extensive references to standard works and to original papers.

The rheological properties of suspensions, emulsions and gels have many characteristics in common best illustrated by a comparison of their visco-elastic behaviour; and much of the recent work described by R. Roscoe, E. G. Richardson and J. J. Hermans in the first three chapters is concerned with the viscosity–concentration relationships of typical examples of the three systems. The theoretical treatment is usually based upon hypothetical models of the molecules concerned; thus, for example, Kuhn, Wall, Hermans and Treloar have developed a theory of long-chain molecular networks applicable to rubber, and Kratky has used a model consisting of chains of rigid rod-shaped crystalline units joined by hinges and embedded in a continuous plastic medium to interpret the behaviour of cellulose gels. In this way, quantitative expressions for force–strain relationships and the volume change on stretching have been derived.

In recent years, a great deal of valuable data on the shape and dimensions of macromolecules and the structural characteristics of gels have also been obtained by a study of the flow characteristics of their solutions. Ch. Sadron and J. J. Hermans have given an excellent account of the theory of Brownian movement as applied to dilute solutions of impenetrable rigid particles and of the equivalent particle concept which has been used by Flory in the development of a theory of viscosity applicable to dilute solutions of flexible chain molecules.

The extensive use of sprays, aerosols and smokes for insecticidal and other purposes has led to further studies of the mechanism of drop formation, distribution of drop-size and rates of dispersion and settlement of aerosols and smokes. E. G. Richardson

gives a comprehensive account of the break-up of liquid jets and the methods of measuring drop-size, while H. L. Green summarizes recent work on the atomization of liquids and the properties of smokes. R. Matalon describes the rheological properties of foam and the methods available for studying the mechanical properties of the stabilizing surface layer of laminæ and bubbles. The concluding chapter by Mrs. B. S. Neumann contains an account of the flow properties of powders.

INTERPRETATION OF EARTHQUAKE DATA

Earthquake Intensity and Related Ground Motion

By Frank Neumann. Pp. v+78+figures 1–16. (Seattle: University of Washington Press, 1954.) 1.50 dollars.

THE author of this booklet is a noted mathematician and was employed for a prolonged period as chief seismologist at the United States Coast and Geodetic Survey, retiring in August 1953. The booklet surveys part of this work and summarizes our present knowledge of this most important part of seismology, including much original and previously unpublished work by the author. It is a publication replete with experience and written with the incisiveness and succinctness of the mathematician.

The old way of determining earthquake epicentres by drawing isoseismal lines required the precise formulation of seismic intensities, and in 1931 H. O. Wood, at the Pasadena Seismological Laboratory, brought up to date the Mercalli–Cancanni intensity scale. Now seismic intensity, which is in effect a measure of the local destructiveness of an earthquake, is made up of a great number of factors, chief among which is probably local ground acceleration. Nowadays, ground acceleration alone is measured by 'strong-motion' seismographs. In 1935, C. F. Richter published an earthquake magnitude scale in which the magnitudes of earthquakes are obtained from the measurements of standard seismograms reduced to standard epicentral distances, and are a function of the energy released by the earthquake. The most recent formula of B. Gutenberg and C. F. Richter is $\log E = 12 + 1{\cdot}8\,M$, where E is the radiated energy and M the earthquake magnitude. Earthquake magnitude does not refer to local energy near the observatory, but to the total energy released at the focus of the earthquake.

Efforts have been made, and are being made, by seismologists throughout the world to define seismic intensity with mathematical precision, obtaining the data from seismograms instead of from human perception and the destruction of buildings, and to relate seismic intensity at any focal or epicentral distance to earthquake magnitude at the focus of the earthquake. This is precisely the task Frank Neumann set himself. In the present booklet he develops a distance–Modified Mercalli intensity relationship, particularly from the data concerning the Puget Sound earthquake of April 13, 1949. The intensities are the lowest intensities and refer to the basement rock outcrop. In all earthquakes the intensity on this formation is reduced approximately one grade whenever the distance is doubled. This distance–intensity graph always indicates an epicentral intensity corresponding to the Gutenberg–Richter magnitude at an epicentral distance of about one mile. Intensities on highly compacted sedimentary rock outcrop are consistently about one Modified Mercalli grade higher than on granitic outcrop at all epicentral distances. A relationship is established between Modified Mercalli intensity and maximum acceleration. This relationship varies with epicentral distance. With increase of epicentral distance the acceleration for a given Modified Mercalli intensity grade decreases, but the duration increases.

Period-acceleration envelopes exhibit the following characteristics. At short epicentral distances they show a peak on the average at about 1/3 sec. period, but the period of the maximum acceleration waves increases with epicentral distance. For the waves of shorter period the rate of increase of acceleration with increase of period is indicative of body-wave propagation and apparently varies greatly with the type of rock traversed and epicentral distance. For waves of longer period the rate of decrease of acceleration with increase of period is practically constant and indicative of layer vibrations in, or related to, basement rock formations. The author develops a technique, employing intensity-acceleration relationships, whereby Modified Mercalli intensities are determined from period-acceleration envelopes. They consistently agree with the intensities obtained from the author's distance–intensity graphs. Further, a quantitative intensity grid developed by the author from the intensity-acceleration and period-acceleration relationships, and valid up to an epicentral distance of approximately twenty-five miles, shows the acceleration or amplitude to expect for any period that may be in the ground motion. Modifications for distances exceeding twenty-five miles are discussed. Grids are developed for period-acceleration distribution when earthquake foci are in the granitic basement, and for period-acceleration distribution when earthquake foci are in the highly compacted sedimentary rock above. Grids are used to interpret period-acceleration envelopes, or individual waves, in terms of Modified Mercalli intensity.

The author states that "since the intensity distribution on basement rock is always very uniform, so-called basement rock intensity data may be used to determine maximum intensity epicentres. These are points of maximum energy release and do not necessarily coincide with epicentres obtained from standard seismograph records, which indicate the location of the first lock break where more than one break occurs. The rapid decrease of intensity on basement rock outcrop with increase of distance in the immediate epicentral area indicates that major lock breaks are quite limited in extent. The intensity distribution in all shocks thus far studied is the same as though the foci were all very shallow regardless of the actual depths revealed by teleseismic data". A casual comparison of period-acceleration envelopes and earthquake spectra obtained from identical instrumental records reveals a marked similarity in their overall forms. Further study, however, is needed to determine to what extent such envelopes may be used as substitutes for earthquake spectra.

The use of simplified ground motions in engineering studies as substitutes for actual ground motions poses a difficult problem. While the quantitative intensity grid as developed by the author furnishes period and amplitude data on earthquakes of different Modified Mercalli intensity, the important element of duration

is missing, as Neumann admits. He suggests, however, a substitute procedure. He further states that a "22-fold increase in acceleration is indicated" when earthquake vibrations passing through the granitic basement force the most responsive types of surface formations into vibration. (The United States Bureau of Mines, while investigating high-frequency explosion waves, found a thirty-fold increase between two extreme types of rock and soil formation.)

The author is at pains to direct attention to the provisional character of all the new relationships put forward in the text, and suggests new types of instruments, which at low cost would assist the practical and theoretical investigations brought to light by this erudite booklet. Engineers concerned with earthquake-proof design and those concerned with insurance in countries liable to earthquakes, no less than all seismologists, will read this stimulating work with interest and profit. ERNEST TILLOTSON

ELEMENTARY APPLIED PSYCHOLOGY

Psychology applied to Human Affairs

By Prof. J. Stanley Gray. Second edition. (McGraw-Hill Series in Psychology.) Pp. vii+581. (London: McGraw-Hill Publishing Company, Ltd., 1954.) 42*s*. 6*d*.

THIS book is designed as a 'class-room text-book' for first-year students in psychology. Its major emphasis is on industrial psychology. The treatment of educational, clinical and medical psychology is very slight. Some of the less orthodox topics it deals with are "Psychology in College Life", "Military Psychology", "Speech Correction", and "Psychology in Marketing and Advertising". Social psychology, too, is represented in chapters on "Public Opinion and Propaganda" and "Crime and Crime Detection". Since the book is written at a fairly elementary level, it is to be expected that the changes from the first edition, published in 1946, are small. The main justification for the new edition seems to be the bringing up to date of descriptions of the practice of some American institutions that make use of applied psychology.

The editor, who is also author of nine of the nineteen chapters, emphasizes that the book aims at being "factual and practical", and "theoretical discussion . . . has been kept at a minimum", and that sometimes, because of limited space, "facts are reported with a minimum of interpretation". Hence "it needs a teacher to interpret the facts", though the editor suggests that by using this as a classroom text-book the teacher can dispense with formal lectures. This may excuse what sometimes appears inconsequent and arbitrary. But the approach could be more scrupulous. Too often results of dubious value are quoted without tests of significance or, in some cases, indication of the number of cases upon which the results are based. The writers take the reader too little into their confidence about the problems and difficulties facing the applied psychologist, and the presentation by topic leads to a neglect of questions of method. The interview, for example, is basic to a number of topics dealt with in this book; but no writer has the space to give it the systematic treatment it deserves. Some good features of this book—statistics showing the need for applied psychology in various fields, descriptions of the institutions that carry it out—are of less value to readers in Great Britain since they refer almost entirely to America. In particular, the very cursory chapters on clinical and military psychology are robbed of their value by this practice.

The standard of text-books in psychology is perhaps a modest one, and by such a criterion this book may not be much below average. But it may be questioned whether its loose, episodic structure makes it a satisfactory compendium of subjects that more specialized text-books in particular fields of applied psychology already cover adequately in university courses. W. H. N. HOTOPF

BIRD PHYSIOLOGY

Avian Physiology

By Prof. Paul D. Sturkie. Pp. xii+424. (London: Baillière, Tindall and Cox, Ltd., 1954.) 48*s*.

ONE might cavil at the use of the above title for a volume that deals essentially with the physiology of the domestic fowl, duck and pigeon. But when we reflect that 90 per cent or more of "text-books of physiology" are in fact text-books of rodent, rabbit and human physiology, any criticism of the title chosen by Prof. Paul D. Sturkie would be a little unfair. The present book is, in fact, probably the first in any language devoted solely to the physiology of birds.

The book deals comprehensively (five chapters) with what is known of avian blood and its circulation, including a chapter on electrocardiography. Three chapters give information on those enormously interesting subjects, avian respiration and the regulation of body temperature. Another one is devoted to energy metabolism, including a statement of what is known (and what is not known) concerning the mechanism that governs moult. Mechanical and chemical aspects of alimentation are dealt with, and there is a chapter on carbohydrate metabolism.

There are also chapters on renal physiology, the special senses (but not the nervous system) and reproduction, together with an account of early embryonic development. The final five of the twenty-one chapters deal with the endocrine glands and their relationships.

This book may become indispensable to the numerous workers in what has become known as poultry science in the United States and elsewhere. It could be valuable, to a limited degree, to the ornithologist who has sufficient physiological grounding to understand it.

The principal criticism that must be made is that, written chiefly for research workers in a very specialized economic field, the book ignores great bodies of available knowledge that vitally need to be written into a single volume. There is nothing about digestion in fish- and flesh-eaters, or the mechanics of, or the remarkable adaptations towards, locomotion. The highly suggestive work of Wood Jones on olfaction in the Turbinares has been ignored and there is little about the neuro-endocrinal control of display, breeding seasons and migration. Perhaps we may hope for a later expansion of the volume to make it truly a text-book of avian physiology. There can be few people better equipped to do this than Prof. Sturkie. A. J. MARSHALL

PRODUCTION OF ENRICHED NON-RADIOACTIVE ISOTOPES AT OAK RIDGE NATIONAL LABORATORY

By Dr. C. P. KEIM
Oak Ridge National Laboratory, Oak Ridge, Tennessee

THE production-scale mass spectrographs at Oak Ridge, originally developed to enrich uranium-235, now provide more than two hundred different enriched isotopes of nearly fifty elements for basic and applied research.

Only four of the large mass spectrographs are in active operation for general isotope separation. These were originally installed to provide training facilities for production personnel and to develop ion sources and isotope collectors to be used in large-scale enrichment of uranium-235. These four mass spectrographs, arranged as pairs in two separate magnetic fields, have proved to be highly versatile in enriching naturally occurring isotopes of many elements from lithium to uranium in mass. Radioactive isotopes, artificially produced, have also been separated to a limited extent.

The Production Mass Spectrographs

These Oak Ridge electromagnetic isotope separators (sometimes referred to as calutrons, since the production models were developed at the University of California, under Prof. E. O. Lawrence) consist of an ion source and an assembly of isotope collector pockets mounted in a vacuum chamber between the poles of a powerful electromagnet. The gap between the poles of the magnet is 12 in. in one case and 24 in. in the other; the magnetic field may be regulated at whatever strength is desired, up to at least 10,000 gauss. The operating vacuum is in the vicinity of 10^{-5} mm. of mercury. Fig. 1 shows the front view of a calutron and Fig. 2 is a photograph of a model of the magnet, the bins and the vacuum pumps.

A suitable charge material of the element, the isotopes of which are to be separated, is vaporized and fed into the graphite ionization chamber. Electrons of a few hundred volts energy from a tungsten or tantalum filament are directed through a collimating slot into the ionization chamber, where collisions with the gaseous charge material result in a high number of positive ions. These ions are then accelerated from the ion source by means of an

Fig. 1. Front view of the calutron assembly showing the magnet yoke, mass spectrograph spaces, and a handling truck on which are mounted an ion source (below) and the isotope collector (above). The left bin doors are open showing the ion source (below) in its port with all electric and water connexions made and the isotope collector (above) ready for operation. The right bin has the lower doors closed to protect personnel from high voltage during operation

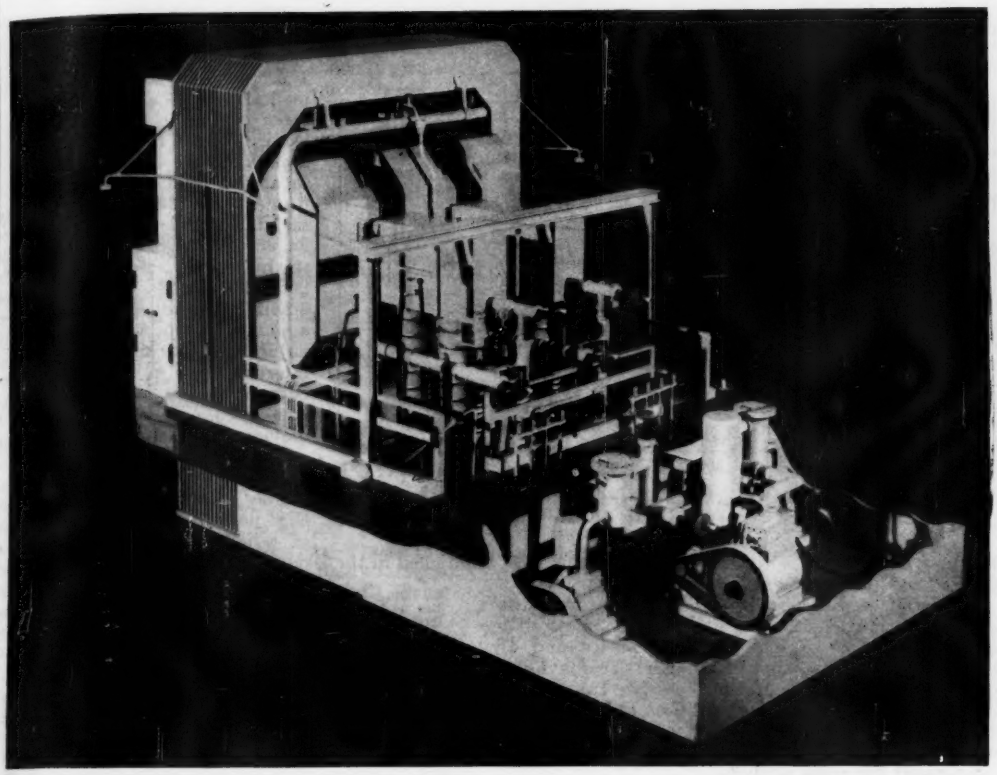

Fig. 2. Rear view of a model of the calutron assembly showing the magnet yoke, three vertical magnet coils, two spaces between the pole-faces of the magnet each for a mass spectrograph, vacuum pumps, valves and piping systems. The mechanical vacuum pumps are on a floor below the main operating level

electric field of 35 kV. As the ions travel across the magnetic lines of force they are further accelerated into a circular path; the radius of travel can be varied from 6 in. up to 48 in.

At the 180° position the ions, now separated according to mass, are directed into isotope collectors at ground potential. Usually the isotopic material is retained in these collectors in its elemental state.

It has been found that the singly charged ions of the element are the most plentiful. Fig. 3 indicates the variety of ions emerging from the ion source during typical operations.

Observations drawn from Processing Experience

Various observations have been made in the processing of nearly a thousand lots of separated isotopes of many elements since early 1946.

The halides have usually proved to be the best charge materials, although oxides and the element itself are sometimes preferred. Ion-source oven temperatures may be successfully operated at temperatures as low as 100° C. up to more than 2,500° C. One or more ionization arcs may be mounted on one ion-source assembly, with corresponding increase in productivity, if there is not too much overlapping of the isotopes at the collector pockets.

Failure of the tantalum or tungsten filaments which supply electrons for ionization is the most common cause of interruption of isotope separation runs. This failure is due to positive ion bombardment and chemical attack.

The percentage of material vaporized from the charge bottle actually getting to the isotope collectors varies widely, from only a few per cent up to as high as fifty per cent, depending on the element being processed.

Graphite collectors are preferable if the collected isotopes have a low vapour pressure and the collector pockets do not require water-cooling. Water-cooled copper collectors have proved best for isotopes of high vapour pressure to prevent high loss of the collected isotopes. Under adequate control, almost one hundred per cent of the material reaching the collector pockets can be successfully retained there.

Every element has its characteristic chemical and physical properties, and the performance of an element cannot be successfully predicted on the basis of the behaviour of similar elements.

Key Steps in Isotope Separation

The key steps in successful isotope separation require various technical skills. Inorganic chemists must aid in the selection of suitable charge materials of the elements to be processed, including rare and unusual materials, then prepare adequate quantities of the chosen forms in high chemical purity. They must recover small quantities of the precious enriched isotopes from the collectors, purify them chemically, and supply them in a variety of chemical forms for

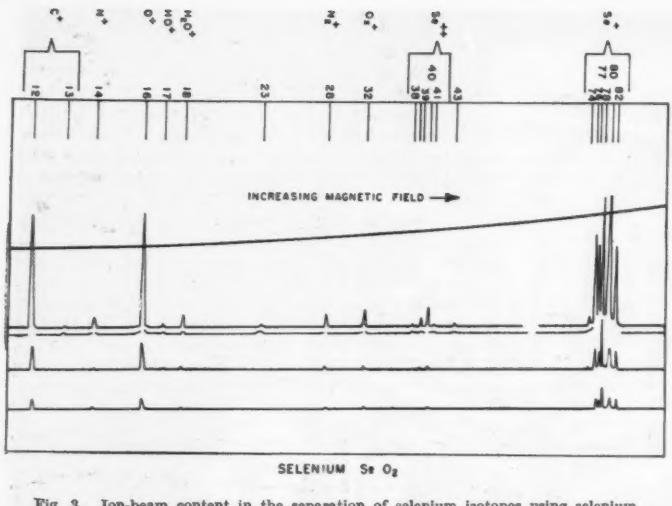

Fig. 3. Ion-beam content in the separation of selenium isotopes using selenium dioxide as the charge material

the user of enriched isotopes. Unusual compounds, pure metals, targets, etc., are often necessary.

The staff of the spectrochemical laboratory must analyse purified isotopes of all the elements so that enriched isotopes of high chemical purity and of reliable analyses are supplied the user. This involves most of the elements of the Periodic Table. An especially valuable discovery has been the adaptation of an iridium filament in the ion source, from which only a few micrograms of an unknown substance are evaporated for mass analysis.

The conversion of the uranium production mass-spectrographs to the separation of isotopes of a wide variety of masses and properties has called on physicists, electronic engineers, mechanical engineers, instrument makers and other craftsmen. The original uranium machines have been improved so extensively that the ion sources and isotope collectors used now resemble only remotely those of a few years ago.

Ion sources for uranium were subjected only to the vapour and ion products of uranium tetrachloride, whereas present ion sources must withstand the action of a wide variety of chemical compounds. The charge material ovens in uranium ion sources were heated to a maximum of 600° C., whereas for some elements now processed more than 2,000° C. is necessary. Only two isotopes of uranium, uranium-235 and 238, were separated, but in the present programme as many as ten isotopes of an element (for example, tin) are collected at one time.

Ionization potentials, process efficiencies, vapour pressures, chemical properties, natural abundances of the isotopes, the difference between adjacent isotopes of an element, and many other factors, influence the behaviour of various elements and compounds in the mass spectrograph.

Production Results

The ion currents registered at the isotope collectors differ widely among the elements. However, collector currents of a hundred milliamperes, representing the ions of all the isotopes of a particular element, are not unusual; these ions originate in a single source.

What production-rate is represented by 100 milliamperes of ion current? From elementary theory, 1 amp.-hr. of singly charged elemental ion deposits 0·0373 gm.-atom of that element in the collector. Hence, 100 m.amp. deposits approximately 26 mgm. per hr. of separated lithium isotopes (masses 6 and 7), or 358 mgm. per hr. of molybdenum isotopes (masses 92, 94, 95, 96, 97, 98, 100), or 772 mgm. per hr. of lead isotopes (masses 204, 206, 207, 208), all distributed among the collector pockets in amounts proportional to their natural isotopic abundance. It is interesting to note that a total current of 100 m.amp. is equivalent to about one billion atoms moving from source to collector every billionth of a second (1 billion = 1,000,000,000).

The following are the elements of the naturally occurring isotopes of which have been successfully enriched in the large Oak Ridge mass spectrographs:

Lithium	Iron	Ruthenium	Samarium
Boron	Nickel	Palladium	Gadolinium
Carbon	Copper	Silver	Hafnium
Magnesium	Zinc	Cadmium	Tungsten
Silicon	Gallium	Indium	Rhenium
Sulphur	Germanium	Tin	Iridium
Chlorine	Selenium	Antimony	Platinum
Potassium	Bromine	Tellurium	Mercury
Calcium	Rubidium	Barium	Thallium
Titanium	Strontium	Lanthanum	Lead
Vanadium	Zirconium	Cerium	
Chromium	Molybdenum	Neodymium	

Only europium, dysprosium, erbium, yttrium and lutetium of the rare earths, the noble gases and osmium have not been processed in the calutrons up to this time. The processing of the rare earths awaits the availability of suitable charge material, and the enriching of the noble gas isotopes awaits the development of appropriate isotope collectors. The solution of both these problems is progressing satisfactorily and there appear to be no insurmountable obstacles.

Typical Examples of Separations

As was stated above, all elements processed in the mass spectrograph have their individual characteristics, which result in a wide variety of performances. Only a few examples will be given.

Lithium. The enrichment of the lithium isotopes was initially tricky. It was difficult to maintain ionization with accelerating potential applied; the addition of a small amount of nitrogen as a 'support' gas was of benefit. Lithium chloride as the charge material gave the largest ion beams, but its reaction, or that of its dissociated components, with the metal from which the ion source was fabricated, produced deposits in the ion exit slit of the ionization chamber, eventually causing termination of the run. The dissociation of lithium chloride to $LiCl^+$, Li^+ and Cl^+ ions is believed to contribute to this deposition. The addition of a few per cent lithium metal to the lithium chloride charge eliminated this trouble. As obstacles were overcome, lithium ion beams at the collectors reached several hundred milliamperes. Because of the large percentage mass difference, lithium-6 and lithium-7 of very high isotopic purity were obtained.

Potassium. Potassium isotopes were enriched, with emphasis on potassium-40. Continued development produced potassium-40 of greater than 10 per cent isotopic purity, its natural starting purity being only 0·012 per cent. Later, using a potassium chloride charge which had been previously irradiated in the pile at Chalk River, several milligrams of 22 per cent potassium-40 were obtained. Pile irradiation had increased the potassium-40 content to about 0·025 per cent by the $^{39}K(n,\gamma)^{40}K$ reaction.

Iron. Iron isotopes, iron-54 (of 22 per cent natural abundance) and iron-58 (of 0·3 per cent natural abundance) are enriched to provide high-purity non-radioactive isotopes, which are then irradiated in the pile to produce radioactive iron-55 and iron-59 of high specific activity. Specially purified graphite isotope collectors must be used to eliminate the destruction of isotopic enrichment in the collectors by natural iron contamination in the graphite.

Ruthenium, platinum, iridium and palladium. These elements have been processed, but not without considerable development. The usual compounds of these elements decompose on heating, so vaporization by ordinary means into the ionization chamber is impossible. Special techniques of heating the metal as high as 2,500° C. by electron bombardment provide an abundance of ions, and many milligrams of enriched isotopes have been collected. Even at only ten milliamperes of ion beam, as much as 50 mgm. of platinum isotopes are collected hourly.

Rare earths. The rare earth elements of atomic numbers 57–71, inclusive, present numerous problems, among which is the obtaining of several hundred grams of their halides for ion-source charge material. Fortunately, a chemical separation of the rare earth elements, using the monazite and gadolinite ores, has provided adequate charge materials for the isotope separation of cerium, neodymium, samarium and gadolinium. Dysprosium charge material is now on hand, and the rarer elements will be available with continued efforts.

A tributyl phosphate – nitric acid liquid–liquid continuous-column extraction system is employed for separating the rare earths into their elements, and best conditions are being developed for concentrating each element. Ion-exchange separation is sometimes used for final chemical purification of the enriched isotopes.

From the foregoing examples it is seen that most elements present special interesting problems in the enrichment of their isotopes in the mass spectrographs. While successfully enriching the isotopes, considerable research is performed in chemistry and physics as well.

Shipments, Uses and Reports

Isotopes, enriched in the Oak Ridge mass spectrographs, were first supplied to Atomic Energy Commission Laboratories in 1946. In the following year university, industrial and other laboratories were able to obtain these isotopes for research and other uses. By the middle of 1954 more than two thousand shipments had been made, and shipments continue at the average rate of one shipment a day. Although these isotopes have been available only on loan to domestic users, a sales programme abroad has now been inaugurated.

New and valuable scientific data on such phenomena as nuclear spins, magnetic moments, hyperfine spectra, isotope shifts, nuclear energy-levels, decay patterns, neutron cross-sections, studies linked with cyclotron and other accelerator bombardments, superconductivity, beta spectroscopy, etc., have been obtained through the use of enriched isotopes.

Several enriched stable isotopes are used in the pile on a recurrent basis to produce useful radioactive isotopes. Other studies show that it is technically feasible and economically advantageous to use certain enriched stable isotopes in the cyclotron to produce radioactive isotopes not now available; initial production has begun.

Although most of these calutron-enriched isotopes are non-radioactive, the enrichment of such radioactive isotopes as beryllium-10, potassium-40, samarium-147 and others has made it possible to clarify their disintegration properties.

Not all the benefits of this stable isotope programme are in the use of the isotope products. Developments in gas discharge, ion sources, mass spectrometry, optical spectroscopy and inorganic chemistry have not only assisted in the enrichment of stable isotopes themselves, but also these developments have contributed to other atomic energy activities, particularly in the reactor field.

Many reports have been written on research made possible by having available enriched stable isotopes. In the *Physical Review* since 1946 more than four hundred such technical papers and abstracts have been published. These unclassified papers have sprung from about forty per cent of all shipments made to users outside the Atomic Energy Commission. This represents about one research report for every two shipments. No information is available on research done with the other sixty per cent of all shipments going into strictly Atomic Energy Commission studies.

The work described in this article results from the co-operative efforts of all personnel in the Stable Isotope Research and Production Division, Oak Ridge National Laboratory, and was carried out for the United States Atomic Energy Commission by Carbide and Carbon Chemicals Company, a division of the Union Carbide and Carbon Corporation.

PRODUCTION OF ELECTROMAGNETICALLY ENRICHED STABLE ISOTOPES AT HARWELL

By Drs. W. D. ALLEN, R. H. DAWTON, M. L. SMITH and P. C. THONEMANN

General Physics Division, Atomic Energy Research Establishment, Harwell, Berks

History of the British Project

IN 1946, when the U.S. Atomic Energy Commission calutrons had already been producing stable isotopes for a year, it was decided to provide facilities at the Atomic Energy Research Establishment, Harwell, for the supply of electromagnetically enriched stable isotopes to nuclear research workers both at Harwell and in British universities. Two 180° machines were built[1], the smaller prototype for the production of nuclear targets by direct deposition from the beam on to suitable backings, and the

Fig. 1. General view of the large electromagnetic separator at Harwell

larger for the separation of gram-quantities of enriched isotopes.

The smaller machine started operation in 1948, and though of rather limited resolution was very useful for making nuclear targets of the lighter elements. Recently this machine was rebuilt as a 2-ft. radius 60°-sector separator for experimental work on ion sources, for separations of the rarer elements, where the source materials are expensive, and for separation of slightly active materials. This facility will be available shortly.

Early in 1950, the larger separator, which is a vertical 180°-machine of 2-ft. radius and somewhat similar in general layout to an early American machine at Berkeley, was started up. Subsequent developments were largely independent of the U.S. effort and there were numerous detailed departures from American practice; for example, in the extensive use of graphite in the source units, design of receivers, and the use of tungsten heaters for source temperatures up to 1,000° C. The machine is now being run on a production basis with shift operators.

Present Production

The outputs and enrichments obtained with the large Harwell separator are broadly similar to the results reported by the Oak Ridge workers for the smaller of their machines, and it is unnecessary here to add to the very complete account of separation experiences given in the preceding article. Owing, however, to the later British start, the inventory is smaller, though thirty-seven elements have been separated and stocks are available of most of them. Principally the lag is in the separation of the elements requiring exceptionally high temperatures, the palladium and platinum groups; mercury, which requires special refrigeration arrangements; and certain elements which are not available in quantity as source materials such as rhenium and hafnium. A start has been made on the rare earths, the cerium and neodymium isotopes being already available.

Applications

Much valuable work has been done and published by British Commonwealth and European workers with stable isotopes from Harwell. Reference may particularly be made to the superconductivity studies on tin[3], the hyperfine spectral work at Oxford, and a

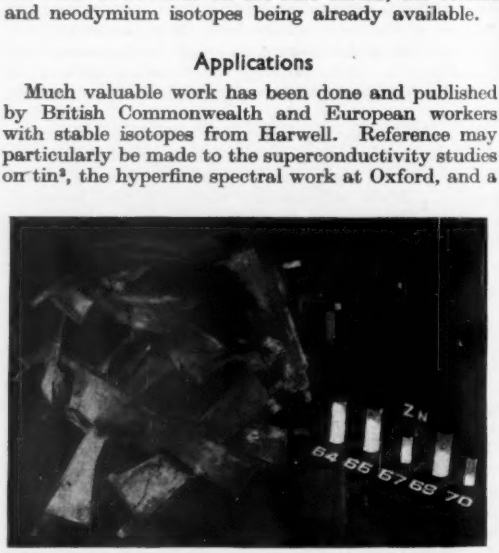

Fig. 2. Chemical processing of zinc isotopes. Photograph of the collectors used (after processing) and the bulk of enriched product as zinc oxide

number of reaction studies too numerous to list here. Large amounts of calcium-44, iron-58 and chromium-50 have also been supplied for the production by pile irradiation of radioactive tracers which have been used in a great variety of researches. So far, 570 separate consignments or targets, ranging in size from micrograms of calcium-46 to 30 gm. of iron-56, have been dispatched to workers at Harwell and in European and Commonwealth laboratories. The output is now about two hundred consignments a year and rising steadily.

Particular emphasis has been laid by the Harwell production group on the provision of targets for nuclear bombardment from the stock of stable isotopes. It was found in early work that targets of elements heavier than magnesium could not be made by direct deposition in the separator because of sputter, and so it was necessary to use a secondary procedure. Such procedures have the advantage, moreover, of starting with a definite amount of material of known purity; providing the most efficient utilization of the stocks; and being very convenient for the users, who can request targets to suit their most varied requirements and obtain delivery within a few days. For preparation of these targets a range of techniques has been adopted including vacuum evaporation, electroplating, painting and thermal cracking, while special attention is paid to the recovery of residues without contamination. In the course of development of these methods, a useful stock of isotopic targets has also been built up.

Some work has also been done on the preparation of gas targets by direct bombardment on to metallic foils, and by this means targets containing oxygen, nitrogen or the rare gases have been made for reaction studies, while following Koch's[3] technique krypton-84 has been recovered from foils for use in spectrographic discharge lamps.

The British Thomson-Houston Co., Ltd., and the Metropolitan-Vickers Electrical Co., Ltd., constructed the large separator; members of the Electromagnetic Separator Group and the Engineering Services Division of this Establishment are responsible for operation and continuing development, while the quality of the isotopically enriched samples is checked by the Mass Spectrographic and Spectrochemical Groups. Sales are made through the Isotope Division.

[1] Allen, W. D., *Nature*, **168**, 451 (1951).
[2] *Nature*, **166**, 1071 (1950).
[3] Koch, J., *Nature*, **161**, 566 (1948).

JOHN RAY, F.R.S. (1627–1705)

By JOAN M. EYLES

JOHN RAY, the seventeenth-century naturalist, has received more attention from the historians of science than many of his contemporaries. The Ray Society has published a memoir and two volumes of his correspondence, and his life and writings have recently been treated in great detail by Dr. C. E. Raven, to whom students of Ray and his times will always be indebted. In addition, a bibliography of his works, by Dr. Geoffrey Keynes, appeared in 1951. It might seem, therefore, that little new remains to be said in this article, which commemorates the two hundred and fiftieth anniversary of his death, on January 17, 1705. Recently, however, attention has been directed to the influence of Puritanism on the development of science in the seventeenth century[1], and the occasion provides an opportunity for outlining Ray's career in this setting, as well as to offer an amendment to Dr. Raven's conclusion that in geology Ray's outlook was "far in advance of all his British contemporaries".

John, the son of Roger Ray, blacksmith, of Black Notley in Essex, received his early education at the little grammar school of Braintree, two miles from his home and thirty miles south-east of the University of Cambridge. At that time the school was held in what is now part of the church. Ray's numerous letters throw remarkably little light on his private life; but those early grammar school days are recalled in a few dry lines in a letter he wrote to John Aubrey many years later: "Neither is y^{r} observation universally true that the sons of labourers and rusticks are more dull and indocile than those of gentlemen and tradesmen . . . but perchance the advantage I had of my contemporaries may rather be owing to my industry than natural parts". Ray's career was certainly built on something more than industry alone.

In 1644, as a sixteen-year-old lad, he entered the University of Cambridge, supported, Dr. Raven surmises, by a local charity intended to maintain "two or three hopeful poor scholars . . . being also of sober and Christian conversation". At that time the Parliamentary forces had already gained the ascendency in their struggle with Charles I, and Ray's arrival at the University coincided with a period of considerable change. Many Fellows, including a dozen heads of colleges who had found themselves unable to accept the Solemn League and Covenant, were being expelled from their offices. During the ensuing Presbyterian regime, religion became something stern and colourless; the parish churches were stripped of their ornaments, and the prayer book and feast-days, including Christmas and Easter, were abolished.

John Ray himself, however, prospered, and in 1649 was elected a Fellow of Trinity College. Two years later he was accepting the usual responsibilities of a young Fellow, and acting in successive years as lecturer in Greek, in humanities and in mathematics. It is true his health was not very robust. An illness about the year 1650 had obliged him to rest for a while from serious study and take more fresh air, a pursuit that had directed his attention to the beauties of the Cambridge meadows, and set him to studying botany. He was unable to find anyone in Cambridge who could instruct him in the subject, so turned to such books as were available, and began to collect plants for "a little garden by his chamber".

In 1655 Ray's father died; and soon after, Ray seems to have arranged for the building of a house called Dewlands, at Black Notley, in which his widowed mother lived until her death in 1679. About this time he began to hold various College offices, and his action in building Dewlands seems that of a man who felt reasonably secure financially. He was not yet ordained, although in normal times it was required of most Fellows. With the return of the bishops in 1660, this was to become a pressing question with him. His earliest surviving letter, written in January 1659, indicates his views at that time. "My present condition is such that I must of necessity enter into orders, or else live at great

uncertainties, and expose myself to the mercy of men for my livelyhood and continuance here. I am not resolved to enter into orders, if so be I stay here, but rather the contrary, it consisting not with those designes which I intend to pursue. Now, if I shall bid farewell to my beloved and pleasant studies and employments, and give myself up to the priesthood, and take to the study of that which they call divinity, I thinke it were the best way to throw myself into the country, and make such provision for this world as other men doe, and make it my business to execute the priest's office". Ray was at this time engaged in preparing his catalogue of Cambridge plants, and the advantage of a country living to one so devoted to botanical pursuits is obvious; but what he had in mind when he wrote of staying in Cambridge, but not taking orders, is not clear. Perhaps he had hopes of becoming a "Physic Fellow" in one of the colleges, which would have exempted him from taking orders. There is little information regarding the teaching of medicine in Cambridge at that time, although several of Ray's contemporaries became physicians. There had been a regius professor of physic in Cambridge since 1540, and in Ray's time this was Sir Francis Glisson, a distinguished physician; but so far as Cambridge was concerned a notable absentee. He had left Cambridge at the outbreak of the Civil War and seldom visited it.

In May 1660, Charles II was welcomed back to England by a people weary of internal wars and religious dissension. Some measure of toleration and individual liberty was promised and expected; but the Puritans, many of whom were ministers of the Church, were soon to be disappointed. We get a glimpse of the state of affairs from a letter written by Ray in September 1660: "Dr. Ferne, who is made master of this colledge . . . came down hither about the beginning of August, with 14 or 15 of the old gang. . . . They have brought all things here as they were in 1641: viz, services morning and evening, surplice Sundayes and holydays, and their eves, organs, bowing, going bare, feasting nights". This gives a clear indication of Ray's Puritan outlook. He wrote in the same letter: "I have long since come to two resolutions, namely, no promise of conformity, and no orders". He must have changed his mind, or been over-persuaded by friends, for three months later he was ordained in London by the Bishop of Lincoln. After this, in three different letters written in June and October of the following year, he stated his intention of leaving the College. He seems to have considered a living in Westmorland but rejected it, partly, he says, because "I find the yearly value to be lesse than it was at first represented".

In May of 1662 the Act of Uniformity received the Royal Assent and Ray knew his days at Cambridge were numbered. The Act required conformity, and a declaration that the Solemn League and Covenant had been an unlawful oath, and it was obligatory for those teaching in colleges and in holy orders. "I have already taken so many oathes & subscriptions as have taught me to disgust such pills", wrote Ray in 1662; and in August, "I shall now cast myselfe upon Providence and good friends. Liberty is a sweet thing. I am hampered enough already, indeed more than I would have been had I foreseen this".

On August 24, St. Bartholomew's Day, some eighteen hundred clergymen were ejected from their benefices for non-conformity, and Ray, who had quietly absented himself from Cambridge at the time, ceased to hold his fellowship.

In his hope for support and encouragement from his friends, Ray was not disappointed. In particular, Francis Willughby, 'virtuoso' and naturalist, a former student with whom he had already made two botanical tours, rallied to his aid. In 1663 Ray, Willughby and two others set off on a tour of the Continent, and to gather materials for a general natural history. It is worthy of note that the universities which they first visited—Leyden, Utrecht and Heidelberg—were all strongly Calvinistic. Willughby returned to England a year later; but Ray and another friend and former student, Philip Skippon, remained abroad until 1666. Shortly after his return, Ray made a botanical tour in Cambridgeshire and Lincolnshire with Dr. Martin Lister, who made some notes about it beginning "Mr. Wray, Mr. Dent & I went out a simpling"[2].

In 1667 Ray was elected to the Royal Society, and during the next five years spent much of his time travelling about England, and at intervals resided at Middleton, Willughby's home in Warwickshire. This nomadic life was brought to an abrupt halt by the sudden and unexpected death of Willughby, then only thirty-seven years of age. Willughby, however, had looked to the future of his friend, and left him an annuity of £60, which was later increased to £72 by his son, Thomas Willughby. This was a generous allowance for the time. According to the tables of Gregory King[3], the average yearly income of "lesser clergymen" in 1688 was £50, and that of "eminent clergymen" £72.

Ray married in 1673, and for a few years continued to live in or near Middleton, working on Willughby's collections and notes. In 1679, when his mother died, he was living in Essex again, and he and his wife then moved into Dewlands, the house he had built and in which he was to reside until his death. His mother's will, drawn up in Ray's neat hand in 1675, shows that the blacksmith's forge was still in the family, for "all tools and utensils belonging to the shop, excepting the iron" were left to her son-in-law, John Tabor; and the rest of her goods and chattels, with the exception of 20*s*. to the poor of Black Notley, were to be divided between her son John and her grandchild Sarah Tabor[4].

From now on Ray devoted himself to the preparation of his botanical works, as well as the zoological works which appeared under the name of Willughby, though Dr. Raven has shown they owed much to Ray's own researches. In 1688 an event of considerable importance to the nation, and particularly to the nonconformists, took place. James II was replaced on the throne by the Protestants William and Mary. In 1689 the Act of Toleration was passed, and this freer atmosphere was praised by Ray in a Latin preface to his "Synopsis Methodica Stirpium Britannicarum", published in 1690. "Superstition has been overthrown. Pure and reformed religion is honoured," he wrote, and in the following year he published a work entitled "The Wisdom of God Manifested in the Works of the Creation", composed largely of sermons he had delivered in Cambridge more than thirty years before. This was followed in 1692 by a more specialized work, "Miscellaneous Discourses concerning the Dissolution and Changes of the World". The latter contained Ray's geological observations and conclusions, and in later editions was entitled "Three Physico-Theological Discourses".

Ray, as Dr. Raven himself states, could go on with his natural history without consciously challenging the historicity of Genesis; but in geology he entered

the arena of conflict. Comparisons are often unfair and sometimes invidious; but Dr. Raven has stated that Ray's outlook in geology was much ahead of all his British contemporaries. These contemporaries were Robert Hooke, Dr. Martin Lister, Robert Plot of Oxford, and two men of a younger generation, Edward Lhwyd and John Woodward. They all discussed the nature and origin of fossils (Lister and Lhwyd in letters to Ray), and it is to this point that Dr. Raven gives most attention. Hooke, in time as well as in accurate and penetrating commentary, takes precedence of them all, for his statement about fossils in "Micrographia" (1665), though short, is to the point. Some account of Hooke's geological ideas, and the period to which they rightly belong, has been given by W. N. Edwards[4] and by A. P. Rossiter[5]. Hooke's geological observations, in addition to those in his "Micrographia", are found in his Cutlerian Lecture, "De Potentia Restitutiva" (1678) and in his "Posthumous Works" (1705). The latter includes the text of two discourses delivered to the Royal Society between June 17, 1667, and September 1668. In none of these does Hooke waver from his view that fossils were genuine remains of once living creatures. Ray, on the other hand, felt obliged (as he wrote in a letter to Lhwyd in November 1690) "to settle in a middle opinion, that some are of one kind, some of another". Lhwyd answered in the same month and in the same vein: "I find in myself no sufficient ability or confidence to maintain either opinion". It is not denied, and there is abundant evidence, that Ray was anxious to believe that fossils were remains of once living things; but he had a fundamental reason for this, made clear in some pages (unnumbered but following p. 162) first inserted in the second edition of the "Discourses" (1693). "For," he wrote, "if we adhere to their Opinions who hold them [that is, the fossils] to have been original Productions of Nature, in imitation only of the Shells and Bones of Fishes: We put a Weapon into the Atheists hands". This weapon, which Ray discusses at some length, was the argument that if fossils were mere sports of Nature, produced without reason or function, then living animals, too, could be produced without "Counsel or Design". Such an argument, difficult for the modern reader to appreciate, struck at the very core of Ray's creed of divine design in Nature. For this reason, above all others, he was constrained to support the view that fossils had once been living things.

Two arguments against this, however, Ray had great difficulty in answering. One, which concerned the Deluge, will not be discussed here; the other was the fixity of species. That species might disappear he had thought "highly improbable"; but many of the fossils then being found could not be matched with living forms, and he could only hazard "that there may be some of them remaining some where or other in the Seas". Hooke had accepted the implication of extinct species; but it was this implication, more than anything else, that seems to have driven Ray to decide finally in favour of an inorganic origin for fossils. Dr. Raven has called this a recantation; but it was rather a reluctant conclusion from the evidence interpreted in the light of Ray's beliefs, evidence that had steadily accumulated as more and more ammonites and Coal Measure plants, which had no known modern equivalent, were discovered by the untiring efforts of Lhwyd, Woodward and other collectors. We can sympathize with Ray in his difficulty; but we must not overlook the clear thinking and bold imagination of Hooke. Thus, there seems no room for doubt that it is Hooke rather than Ray who deserves Dr. Raven's encomium. It must be stressed, however, that the advances in geology were made not by the theorists but by field-workers. The latter include John Woodward, whose theories were weak, but who insisted on the importance of accurate field records.

The last fifteen years of Ray's life were spent in constant pain and illness, but his industry never slackened. He was indeed, as H. B. de Saussure wrote in 1779, "le Naturaliste le plus universel que l'Angleterre ait produit".

[1] See especially, Merton, R. K., "Science, Technology and Society in Seventeenth Century England", *Osiris*, **4**, 360 (1938).
[2] Bodleian MS., S.C.25268, ff.421–441. quoted from Goulding, R. W., "Martin Lister, M.D., F.R.S.", Rep. for 1900 of Architect. and Archæol. Soc. of the Counties of Lincoln and Nottingham.
[3] Quoted from "English Social History", by G. M. Trevelyan.
[4] Original will at Somerset House, Comm. Ct. Lond. (E. and H.), 1679.
[5] Edwards, W. N., "Robert Hooke as Geologist and Evolutionist", *Nature*, **137**, 96 and 455 (1936).
[6] Rossiter, A. P., "The First English Geologist", *Durham Univ. J.*, **29**, 172 (1935).

OBITUARIES

Prof. H. S. Carslaw

THE death occurred on November 11 at the age of eighty-four of Horatio Scott Carslaw, emeritus professor in the University of Sydney, and Fellow of Emmanuel College, Cambridge, professor of mathematics in the University of Sydney during 1903–35. Carslaw held the degrees of doctor of science of Glasgow and Cambridge, and the honorary degree of doctor of laws of Glasgow.

Carslaw served the University of Sydney through a period of great expansion. He had precisely that balance of qualities which best fit a man to raise a small department, not very different from a 'sixth form', to a university school of mathematics with a world-wide reputation for its published work and for the quality of its graduates. He had a vigorous personality of the type around which legends collect, he was a mathematical scholar of distinction with a gift for clear exposition, and he was enthusiastic in his mathematics and aroused enthusiasm in his students.

During his tenure of the chair, the University of Sydney grew from a family affair of a few hundred students to a complex organism of four thousand students in ten faculties. In particular, this period saw the rise of the Faculties of Science and Engineering. In large measure the high standing of Sydney engineering graduates was due to Carslaw's influence on the shape of the course. His locally famous 'little book' bears the title "An Introduction to the Infinitesimal Calculus: Notes for the Use of Science and Engineering Students". His first- and second-year pass courses had very much the needs of these students in mind. The book is one of those that a lecturer likes to use as a basis for a lecture course; the text is little more than a record of leading results, there are plenty of examples, and the lecturer has scope for his own elaboration and development of the subject.

Carslaw played a large part in the development of the State (New South Wales) secondary education system, in particular in the formulation of the mathematics syllabus and its examination at the Leaving Certificate. Between 1911 and 1916 he published a series of articles and reports, under such

titles as "The Teaching of Elementary Mathematics" and "Secondary Education in Australia", which have done much to give direction and purpose to mathematical teaching in the State right up to the present time.

Carslaw's interests in mathematics were wide, as a list of his principal works shows: "An Introduction to the Theory of Fourier Series and Integrals and the Mathematical Theory of the Conduction of Heat", first published in 1906 and rewritten and published as two separate volumes in 1921; "Plane Trigonometry" (1909); "Elements of Non-Euclidean Plane Geometry and Trigonometry" (1916); and "Operational Methods in Applied Mathematics" (1948, with J. C. Jaeger). Each of these contains work which is Carslaw's own contribution to the subject. The earlier works were many times reprinted and were standard text-books for more than a quarter of a century. The "Fourier Series" and the "Conduction" were translated into Japanese, and the "Conduction" was reprinted and widely circulated in the United States during the Second World War.

From 1916 onwards he published from time to time articles in the *Mathematical Gazette* and elsewhere on "Progressive Income Tax", and was consulted by the Commonwealth Treasury on the formulæ to be adopted, the aim of the formulæ being to give a continuous increase of rate of tax over quite a long range of incomes; such formulæ were in use until quite recently.

After retiring from the chair of mathematics in Sydney in 1935, Carslaw spent all his time on his small orchard property at Burradoo, eighty miles from the University, and only rarely went to the city. But his interest in mathematics continued unabated, until within the past three years failing sight made it impossible for him to continue. After the War, while in his late seventies, he had several years of fruitful collaboration with one of his students of twenty years earlier, now Prof. J. C. Jaeger. The fruits of this collaboration were the revised third edition of the "Conduction", and the "Operational Methods" mentioned above.

In 1907 Carslaw married Ethel Maude, the daughter of Sir William Clark, but she died within the year. Thereafter, Carslaw took little part in the social life of the University of Sydney; but he contributed with his characteristic vigour and vivacity to all other phases of University activity. T. G. Room

Sir Frederick McMaster

Sir Frederick Duncan McMaster died at his home at Dalkeith Station, Cassilis, N.S.W., on November 28. He was one of Australia's best-known pastoralists and a prominent studmaster. One of his main interests was breeding merino sheep, and he gradually built up the world-famous Dalkeith Stud. Sheep from this stud won many prizes in competition, and at one time a ram from this stud held the world's record for the greatest price.

Sir Frederick was interested in and supported many plans for the improvement of Australia's pastoral industry. He was always anxious and willing to help the small man. On one occasion he presented the Government with five hundred merino rams valued at £4,000 for distribution to small-scale farmers who had been badly affected by the depression. He was also interested in beef-cattle breeding. His success was well recognized by many prizes at the Sydney Royal Show.

In 1929 the Prime Minister made an appeal for public support for research into Australian primary industries. Sir Frederick responded by the presentation of £20,000 for the erection of a laboratory for the investigation of animal health problems. This laboratory, known as the McMaster Animal Health Laboratory, was erected for the Commonwealth Council for Scientific and Industrial Research at the University of Sydney. A great deal of invaluable research has been done at this laboratory. When it became known to Sir Frederick in recent months that the McMaster Laboratory was in urgent need of additional space, he spontaneously instructed his solicitors to arrange for Commonwealth bonds to the value of £52,800 to be made available to the University of Sydney for the erection of a wing to the Laboratory.

Sir Frederick took a keen interest in research, particularly in agriculture. He was a member of the N.S.W. State Advisory Committee of the Commonwealth Scientific and Industrial Research Organization for many years. He provided facilities on his own properties for scientists to carry out field-work, and leased 2,000 acres of Hinchinbrook Estate to assist scientific research. He was a keen observer and co-operated with the Meteorological Office in obtaining and keeping complete meteorological records. He was a prominent member of the Royal Agricultural Society of New South Wales and also an honorary life member of the Royal Agricultural Society of England.

Sir Frederick was born in 1873 and was educated at the Sydney Grammar School. In 1934 he was created a knight bachelor in recognition of his great services. By his death, Australia has lost a great pastoralist, a keen supporter of scientific work, and a generous benefactor. J. R. A. McMillan

NEWS and VIEWS

Sunspots of the New Cycle

The Astronomer Royal reports the appearance of two sunspots that are the first sizable spots of the new eleven-year cycle. Particulars of these are as follows:

Date on sun's disk	Central meridian passage (U.T.)	Latitude	Area
Jan. 2–14	Jan. 8·1	20° N.	400
Jan. 7–19	Jan. 13·1	36° N.	800

The areas were measured on January 9, the previous days having been overcast. The unit of area is one-millionth of the sun's hemisphere. In addition to the above two spots, an earlier one (probably of comparable size) was observed at Edinburgh on December 30 during the overcast period at Herstmonceux. This spot group, in latitude 24° south, must have developed suddenly between December 28 and 30, and would have passed off the sun's disk on January 5.

The sunspot cycle, with its great peak of activity in 1947, presumably ended just before the middle of 1954. There has been the characteristic overlap in latitude of the old-cycle spots petering out in equatorial regions and the increasing incidence of the small new-cycle spots in latitude 20°–40°. Any remaining doubt concerning the epoch of minimum significant to 1954·4 is now removed by the appearance of these definite spot groups, indicating that the new eleven-year cycle has now definitely begun.

William Sharp (1805–96)

To his medical colleagues, William Sharp, who was born at Armley, near Leeds, one hundred and fifty years ago, on January 21, 1805, was known as a vigorous champion of homœopathy; but he is also remembered as a pioneer of science teaching in public schools in Britain and also of the local museum. Educated at Wakefield Grammar School and at Westminster School, he was articled to an uncle, a Bradford surgeon, in 1821. After attending the United Borough Hospitals in London, he was licensed by the Society of Apothecaries in 1826 and became a member of the College of Surgeons of England in the following year. In 1829 he was elected surgeon to the Bradford Infirmary, and succeeding his uncle in 1833, he had one of the largest general practices in the West Riding of Yorkshire. He founded the Bradford Philosophical Society and served as its first president. At the Birmingham meeting of the British Association in 1839, he advocated the establishment of local museums for the display of exhibits of particular interest to the district. Shortly afterwards he was elected a Fellow of the Royal Society. While in practice at Hull, he lectured on chemistry at the Hull and East Riding School of Medicine, and afterwards was responsible for the introduction of science teaching at Rugby School—an example soon followed by other public schools. Sharp wrote some sixty tracts on homœopathy. Stressing the opposite actions of large and small doses of the same drug, he tried to reconcile homœopathic and allopathic teaching. One of his best-known works was "Therapeutics founded upon Organopathy and Antipraxy" (1886). Sharp received the M.D. from the Archbishop of Canterbury in 1856 and died at Llandudno on April 10, 1896, aged ninety-one.

Chief Librarian of the Commonwealth Scientific and Industrial Research Organization

Miss E. L. Archer, chief librarian of the Commonwealth Scientific and Industrial Research Organization, Melbourne, has retired. Miss Archer has had a longer association with the Organization and its predecessors than any other member of the staff. She has built up the library system of the Organization over a period of thirty years, and her responsibility extends beyond the management of the library at head office to include the supervision of more than thirty divisional and sectional libraries distributed through every State of the Commonwealth of Australia. She has done much to raise the status of librarians in Australia and to gain recognition for library work as a specialist profession, and was the first woman federal president of the Australian Institute of Librarians in 1948. Miss Archer was born and educated in Melbourne, and holds the degree of M.Sc. of the University of Melbourne with honours in botany. She made a special study of the use of the Universal Decimal Classification and introduced it into the libraries for which she was responsible after a visit to Europe, including Great Britain, during 1936.

Coding in Plant and Animal Taxonomics

Two meetings have been held at the Chemical-Biological Coordination Center, National Research Council, Washington, D.C., "to explore the possibility and desirability of developing a unified system for coding plant and animal taxonomic entities". Unfortunately, no samples of proposed systems of coding are given. Apparently the idea is that every taxon shall be given a 'code number' built up of figures indicating designation, ordinal relationship, and description. Since taxonomy is dynamic, not static, with, one hopes, its methods and results constantly progressing, it is difficult to envisage a code that would not require frequent revision. However, supplementary data may clear up some of the doubts that arise when one envisages an elaborate scheme in practice. Taxonomists wishing for further information should apply to Dr. G. Congdon Wood, Chemical-Biological Coordination Center, National Research Council, 2101 Constitution Avenue, N.W., Washington 25, D.C., U.S.A. An outline scheme for taxonomic coding was given, apparently quite independently of the meetings referred to above, in *Chronica Botanica*, **12**, 211 (1951).

Stalk Borers of the Tropics

The stalk borers of graminaceous crops in the tropics are chiefly lepidopterous caterpillars. In the aggregate they levy a heavy toll on the world's food supply; but because their action is insidious, occurring year after year to a varying extent, but without such spectacular effects as the locust may bring about, their importance is often overlooked and effective action is seldom taken. Indeed, in most regions there is no reliable assessment of the damage they cause. Moreover, the prior attention of entomologists has usually been given to insect pests of plantation crops in which the prospects of early control are generally more promising. At the present day two factors are tending to remove this indifference: the insistent demand for increasing the food production of the world, and the development of synthetic insecticides which may prove applicable in tropical peasant agriculture. It is therefore timely that Dr. W. P. Jepson should have produced a "Critical Review of the World Literature on the Lepidopterous Stalk Borers of Tropical Graminaceous Crops" (pp. vi+127. London: Commonwealth Institute of Entomology, 1954; 15*s*.). Here, for the first time, all the available information on this subject has been brought together.

Archæology of Deneholes

The "Proceedings" for 1954 of the Croydon Natural History and Scientific Society contains interesting articles on deneholes and on Croydon itself. Deneholes are excavations in underlying chalk reached by vertical shafts through the overload. They often consist of a number of chambers, and the excavations were carefully and scientifically done. The vertical shafts—sometimes 30–40 ft. deep—can be dangerous and so have frequently been plugged. It sometimes happens that the plugs themselves collapse into the underlying cave, as has recently occurred at Waddon. This gave an opportunity for investigation before the plug had to be reinstated. The age of the deneholes seems to be pre-Roman, and they are probably of the Iron Age. Many explanations have been given as to why they were made; but none is satisfactory. Underground granaries or stores have been suggested, or pits for obtaining chalk for agriculture; but, if the latter explanation be the correct one, why have they been so carefully made? Drainage sumps, places of worship, underground dwellings and secret refuges, or burial places have all been suggested from time to time. It would seem clear, however, that some connexion must exist between these artificial caves and the earth-houses

of northern Scotland. But unfortunately we do not really know why these latter were made, either.

Making and Measuring Gauges

During the Second World War a booklet dealing with the making and measuring of gauges was prepared by the staff of the National Physical Laboratory, Teddington, as a war-time aid to firms who were entering the field of gauge-making for the first time, and a new and revised edition of this booklet has now been issued as No. 5 in the series of "Notes on Applied Science" under the title of "Gauge Making and Measuring" (pp. 79+1 plate. London: H.M.S.O., 1954; 3*s*. net). The Notes touch upon both the manufacture and measurement of gauges and, in addition, include descriptions of measuring equipment suitable for this class of work. Only the simpler types of plain and form gauges are considered, as screw gauges are adequately dealt with in No. 1 of the series. Much information which should be already familiar to experienced gauge-makers is included; but several novel topics are also discussed. The contents consist of four parts. Part 1, which is of a general and introductory nature, refers to the general requirements of gauges as to marking, dimensions, hardness and finish in accordance with British Standard specifications. The serious errors that can arise in the measurement of gauges as a result of thermal expansion are particularly emphasized. Part 2 deals with the selection of suitable steel for gauges and with the detailed techniques for machining, hardening, stabilizing and grinding the blanks, and with other workshop methods, some novel, involved in gauge-making. Parts 3 and 4 are devoted to measuring apparatus commonly used in gauge-making and describe bench micrometers, vertical comparators and using light in measurement. "Gauge Making and Measuring" is a valuable addition to the literature on metrology and should be of particular assistance not only to gauge-makers but also as a text-book for students who are studying metrology as a subject in the National Certificate Examinations.

Chemical Abstracts: New Greek Journal

The Centre of Bibliographical Investigation in Athens has begun to publish a monthly abstract journal, *Chemical Research*, dealing with pure and applied chemistry. This contains abstracts in Greek of papers published in journals of all countries; but there is an appendix, which in the copy received is in English, French and Italian, of abstracts of papers published in Greece. This appendix will serve to direct attention to publications of Greek chemists, and, since one of the abstracts is of a doctoral thesis of the University of Athens, it is likely to refer to publications which could otherwise be missed. The journal is published from 44 Charocopou Street, Kallithea, Athens.

Earthquakes during May–September 1954

Forty-seven earthquakes having instrumental magnitude 6 or greater occurred during May–September 1954. The greatest (magnitude 7¼) occurred on September 17 in the region of the Fiji Islands. The earthquake with the deepest focus (600 km.) also occurred in the Fiji Islands region on September 15. Earthquakes were reported as having occurred in Europe as follows: Greece and adjacent countries (5), Switzerland (7), Spain (5), Jan Mayen Island (3), Germany (1), Belgium (1) and Norway (1).

Textile Institute: Medal Awards

The following awards have been announced by the Textile Institute: the Institute Medal, awarded for distinguished services to the textile industry in general and to the Institute in particular, to Mr. W. Crossley, managing director of the Yorkshire Dyeing and Proofing Company, Ltd., Middleton, Lancs; and to Dr. P. W. Cunliffe, research manager of the British Cotton and Wool Dyers' Association, Ltd.; the Institute Service Medal, awarded in recognition of valuable services to the Textile Institute, to Mr. E. J. D. Poole, senior principal technical officer of the Wool Industries Research Association; Mr. L. Morris, textile chemist with Allied Colloids (Manufacturing) Co., Ltd.; and Mr. J. R. S. Goodall, of Stockport.

N.Z. National Research Fellowships (1955)

The Minister of Scientific and Industrial Research, New Zealand, has awarded the four National Research Fellowships to be taken up during 1955 as follows: Dr. H. C. Clark, junior lecturer in the Chemistry Department, Auckland University College, who will carry out research at the University of Cambridge; Mr. H. V. Brewerton, a chemist at the Dominion Laboratory (N.Z. Department of Scientific and Industrial Research) at Wellington, who will work on the chemistry of the extractives of New Zealand timbers at the University of Nottingham; Mr. P. H. Fitzgerald, a plant breeder at the Crop Research Division of the N.Z. Department of Scientific and Industrial Research, who will work in the Genetics Department, University of Adelaide; Mr. J. D. Lovis, of the Department of Botany, University of Leeds, who will work in Canterbury University College. These Fellowships are offered annually to suitable applicants with postgraduate experience in scientific research to enable them to study at New Zealand or overseas institutions. Each Fellowship has a value of £600 a year, an additional £100 a year being paid to a married man. Grants of up to £50 for books, fees, etc., and up to £150 for travel are also paid. The tenure of a Fellowship is for one year with provision for an extension by a further year where such extension is justified.

Conference on Mass Spectrometry

The Third Annual Conference on Mass Spectrometry under the sponsorship of Committee *E*-14 of the American Society for Testing Materials will be held during May 23–27 at the Mark Hopkins Hotel in San Francisco, California. All aspects of the theory and application of mass spectrometry will be covered. Titles of papers should be submitted by February 15 to Mr. William Priestley, jun., Standard Oil Development Co., Box 121, Linden, New Jersey. There will also be an exhibit of mass spectrometry equipment, information about which can be obtained from Dr. J. G. Hutton, General Electric Co., 1 River Road, Schenectady, New York.

Colonial Service: Recent Appointments

The following appointments have recently been made in the Colonial Service: J. S. Blacklock (agricultural officer, Sarawak), agricultural officer, Northern Rhodesia; L. H. Brown (agricultural officer, Kenya), provincial agricultural officer, Kenya; T. N. Greeves (senior agricultural officer, Northern Region, Nigeria), deputy director of agriculture, Sierra Leone; N. M. Lucie Smith (assistant director of agriculture, Gold Coast), director of agriculture,

Mauritius; A. Storrar (agricultural officer, Kenya), provincial agricultural officer, Kenya; B. C. Wills (agricultural officer, Northern Rhodesia), assistant director of agriculture (field services), Kenya; P. A. Allison (senior assistant conservator of forests, Nigeria), conservator of forests, Western Region, Nigeria; H. B. Burgess (senior assistant conservator of forests, Nigeria), conservator of forests, Western Region, Nigeria; J. W. Henderson (assistant conservator of forests, Gold Coast), senior assistant conservator of forests, Gold Coast; L. M. Bear (geologist, Kenya), geologist, Cyprus; A. M. Guennel (assistant director), deputy director of the Geological Survey, Tanganyika; A. W. Peers, agricultural officer, Kenya; P. B. Harris, agricultural officer, Northern Region, Nigeria; H. E. G. Morgan and R. F. A. Murfitt, agricultural officers, Sierra Leone; F. B. Lyons, chemist, Department of Chemistry, Singapore; O. Von Knorring, chemist, Geological Survey Department, Federation of Malaya; R. Cross, fisheries officer, Northern Region, Nigeria; K. B. Meecham, fisheries officer, Gold Coast; T. M. Dow, assistant conservator of forests, Northern Rhodesia; R. H. Graham, assistant conservator of forests, Western Region, Nigeria; R. G. Lowe, assistant conservator of forests, Northern Region, Nigeria; W. D. Clayton, specialist officer (ecologist), Federation of Nigeria; J. W. Millbank, scientific officer, East African Agriculture and Forestry Research Organization, East Africa High Commission; P. F. Prevett, scientific officer, Sierra Leone; J. Quarterman, scientific officer, East Africa High Commission; F. Raw, senior scientific officer (entomologist), West Africa Cocoa Research Institute, Gold Coast; P. B. H. Tinker, scientific officer (chemist), West Africa Institute for Oil Palm Research, Federation of Nigeria; T. Williams, plant pathologist (scientific), North Borneo.

Announcements

We regret to announce the death of Sir Arthur Keith, F.R.S., master of the Buckston Browne Research Farm, formerly Hunterian professor in the Royal College of Surgeons, on January 7, aged eighty-eight.

The Paris Academy of Sciences has made the following awards, among others: Lavoisier Medal to Prof. F. Joliot and Mme. Joliot, on the occasion of the twentieth anniversary of the discovery of artificial radioactivity; Henri Poincaré Medal to Prof. G. Valiron, for distinguished work in mathematics; Prix Le Conte (350,000 francs) to M. Lucien Bull, of the Marey Institute, for his work in devising equipment for ultra-rapid cinematography, clinical electrocardiography, application of the electric spark to the cinematography of shock waves, etc.; Prix Osiris (1,000,000 francs) to Emile Borel, for distinguished work in mathematics.

Dr. Irvine C. Gardner, chief of the Optics and Metrology Division of the U.S. National Bureau of Standards, has been awarded the Frederick Ives Medal for 1954 of the Optical Society of America, for distinguished work in optics and his leadership of others, which have "done much to stimulate progress in geometrical optics in this country". This Medal, awarded biennially until 1951 and annually since then, was endowed in 1928 in honour of Frederick Ives, who was distinguished for his pioneer contributions to colour photography, photo-engraving, three-colour process printing, and other branches of applied optics.

The Council of the Institution of Electrical Engineers has elected Mr. J. R. Beard to honorary membership of the Institution for his distinguished services to the profession, more especially in the field of the transmission and distribution of electricity and for his valuable services to the Institution. The thirty-third award of the Faraday Medal of the Institution has been made to Sir John Cockcroft, director of the Atomic Energy Research Establishment, Harwell, for the conspicuous services he has rendered to the advancement of electrical science, and for his distinguished work in the field of nuclear physics and the development of power from nuclear sources.

The Road Research Laboratory (Department of Scientific and Industrial Research) is to hold open days this year at both the Materials and Construction Division at Harmondsworth, Middlesex, and the Traffic and Safety Division at Langley, Bucks, on May 12 and 13. The Scottish Branch of the Laboratory at Thorntonhall, near Glasgow, will be open to visitors on June 2 and 3.

The fourth annual conference of the Aslib Aeronautical Group will be held at Cranfield during April 1–3. The main discussion will centre on classification; and co-operating in the conference will be the Classification Research Group. Full particulars may be obtained from C. W. Cleverdon, Librarian, College of Aeronautics, Cranfield, Bletchley, Bucks.

A symposium on molecular structure and spectroscopy will be held in the Department of Physics and Astronomy, Ohio State University, during June 13–17. There will be discussions of the interpretation of molecular spectroscopic data as well as of methods for obtaining such data. In addition, there will be sessions devoted to those phases of spectroscopy of current interest. Further information can be obtained from Prof. H. H. Nielsen, Department of Physics and Astronomy, Ohio State University, Columbus 10, Ohio.

W. G. Pye and Co., Ltd., Granta Works, Cambridge, have issued a new illustrated catalogue, Catalogue *J*, which supersedes all previous issues and includes only those instruments which are in current production. The instruments described are grouped into eight sections: electronic and associated instruments, including geophones, *p*H meters and Pirani and ionization gauges; galvanometers, electrometers and accessories; general physics, mostly for student use and including many pieces of apparatus designed by the late Dr. G. F. C. Searle; magnetic instruments; measuring microscopes, cathetometers and accessories; miscellaneous items, including switches and clocks; potentiometers; and resistance bridges and boxes.

The Medical Research Council invites applications for a further series of fellowships in clinical research of the value of £850 a year, tenable at centres in the United Kingdom during the academic year 1955–56. These fellowships are ordinarily restricted to medically qualified British subjects resident in the United Kingdom. Applications must be sponsored in each case by the head of the appropriate department in the candidate's university or medical school. Forms of application for these fellowships may be obtained from the Secretary, Medical Research Council, 38 Old Queen Street, London, S.W.1, to whom they must be returned not later than March 1.

INDUSTRIAL MANAGEMENT IN EUROPE

UNDER the auspices of the British Institute of Management, an outstandingly successful conference was held at Torquay during October 20–23. This was attended by 1,070 delegates, 350 of whom came from European countries as far afield as Yugoslavia and Turkey in the east, Finland in the north and Malta in the south. In addition, there were fifty delegates from Commonwealth countries, North and South America, the Philippines and Iceland. The largest single delegation outside the United Kingdom came from Germany, with the Netherlands and Scandinavia second and third.

The papers covered all aspects of management, and one of the most interesting was presented by M. Pierre Bezier, directeur des méthodes mécaniques, Régie Nationale des Usines Renault, Billancourt, who spoke about the implications for management of automation; this is particularly important for industrialists who have to instal and develop the means necessary to launch mass-produced products. The acquisition of all the machines necessary for a new manufacturing programme, according to M. Bezier, is only possible if a machine-tool industry is in existence which is capable of satisfying a heavy demand within a reasonable delivery time; and such an industry can only exist if a sufficiently large group of customers is available to ensure a steady flow of orders and regular and sufficient work. These conditions obtain in the United States, where the domestic market is able to take all the output of the automobile industry and a large part of the domestic equipment industry such as washing machines, refrigerators and plumbing and heating equipment. European factories generally have to fall back on American manufacturers or on local industry for their machine tools. Most British motor-car factories are in this position.

Experience in the use of special machines has made it possible to lay down certain simple rules which can reduce the consequences of unforeseen breakdowns; great importance is attached to the standardization of equipment. Equipment should be sufficiently strongly designed to withstand several years of intensive operation; it should also be 'flexible'. It is particularly useful to avoid units with a short stroke, as this can cause difficulty when tools are changed; 12 in. travel should be considered as a minimum.

Many machine builders have remained faithful to hydraulic controls; M. Bezier prefers electromechanical systems, the principal advantage of which is that they can be applied equally to drilling, tapping or milling cycles. When a piece of equipment goes out of service as a particular model is withdrawn, it is possible to turn it to some other kind of work. When a machine begins to show signs of wear and it becomes difficult to continue with precision work, drastic overhauls must be carried out. The standardization of machine elements enables this to be completed in a few days.

For a long time it was considered that the personnel operating expensive and complicated machines ought to be provided with extensive technical training; and that it would be necessary to envisage a high proportion of supervision and maintenance personnel. These two fears have been shown to be without foundation.

Discussing the application of psychology to industrial training, Mr. A. T. Welford, director of the Nuffield Research Unit, Cambridge, stated that whereas studies of learning form a very large part of experimental psychology in the laboratory, little use has been made of them in problems of industrial training. This is a field ready for development. First, there is much recent experimental evidence that performance after training is better if the training has been on a task a little more difficult than that for which the man is being prepared. Second, there appears to be a growing tendency for the ability to state in words what has to be done to be taken as a criterion of proficiency at a task. Many skills are not easily put into words, and it seems possible that trying to do so may, in fact, distort the emphasis upon particular features and so tend to disrupt rather than assist the free exercise of the skill.

The third point about training is that the way in which a task is performed the first time it is met can sometimes have a profound influence upon how it is performed afterwards. In other words, it is more difficult to modify a method of work already learnt than to learn it in the first instance—a principle well known in games. This means that attention to the initial stages of training is very important; it is better that a complex operation should be broken down into a number of very small units, each of which can easily be mastered on its own, although together they would be very difficult. Rapidity of training is not always the best criterion of its success, and more time spent during training may be rewarded by better performance later, which in turn may lead to greater satisfaction in work and lower turnover of labour.

Another outstanding paper was that read by Prof. G. Lehmann, director of the Max-Planck-Institut für Arbeitsphysiologie. He discussed the physiological principles in the rational organization of work and, *inter alia*, showed that, in building, it has proved to be more economical to use large-sized bricks of a weight of 20–30 kgm. made of a material with a low specific gravity rather than the smaller ones now used. With them it is possible to erect a brick surface six times as large as one built with normal-sized bricks at the same cost of energy. The reason for this remarkable state of affairs is that often more than 90 per cent of the total energy spent is used not for the transport of work pieces and tools but for the movements of the human body. The employment of big and inert limbs for the transport of a small brick is uneconomical. Fewer movements with heavier loads are therefore more advantageous.

Prof. Lehmann showed that the effect of rest pauses is much greater if they are spread evenly over the working day. The best results are achieved if the pauses are taken in relation to the physiological performance curve over the day; that is, if there are fewer rest pauses in the morning when the men are at their best, and more after the beginning of work, or around midday and evening. Generally, many short pauses are more effective than a few long ones of the same total duration. This follows from the fact that recovery follows an exponential curve, setting in rapidly and continuing more and more slowly.

Short obligatory rest pauses should be established in industries. If on observing physically light work one finds that 15 per cent of the time is spent on

real pauses, and a further 15 per cent is spent for ancillary work, part of which, too, stands for hidden rest pauses, it might seem useless to introduce further obligatory rest pauses; results show the contrary. If for every hour an obligatory pause of five minutes is introduced, the number of arbitrary pauses diminishes, together with the time spent on ancillary work. The gain in effective working-time—and therefore production—exceeds by far the loss caused by the introduction of the short obligatory pauses.

For the management of a plant it is important to know whether the limiting factor of production is to be found in the worker or with the technical equipment. Sometimes output does not rise, or even diminishes, after some machine has been replaced by a more efficient one. The reason may be that the worker has lost some of the rest pauses which had been essential for his performance.

The closing address was given by Dr. D. U. Stikker, Netherlands Ambassador to Great Britain, who suggested that in examining responsibility for social questions the task of management is really enormous. Wherever the principle of social responsibility is accepted, profits are increased; but where these principles are not accepted, unrest prevails and all the devices of efficiency are of no avail. In Holland, during the Second World War, when the country was being stripped of its wealth, there was a small group of people—some trade union leaders, some managers and a few politicians—who saw quite clearly that the only way to tackle the problem of reconstruction after the War was by the closest co-operation between labour, management and the Government. At that time management accepted its social task and so did labour, and together they created a new institution known as the Foundation of Labour, a body which has done much to build up the prosperity of Holland. This experiment is unprecedented—an experiment in which organized labour and management came together on a permanent basis in one institution to produce a national wage policy in an endeavour to keep price-levels down and to study plans for social security which were submitted to the Government. The years of social peace that followed the setting up of this new institution can be illustrated by the decreasing figures of working days lost through labour disputes. In 1953, with a population of 10,000,000 people, not more than 30,000 working days were lost; in 1954 there were practically no further strikes and it was deemed unnecessary to publish figures concerning labour disputes. As this institution came into being on the initiative of management, it would seem that management, at the present time, can play a completely different part from the old days, when it was believed that profit-making in itself was a sufficient contribution to the national welfare.

Looking at the different systems in existence in the world to-day, Dr. Stikker said that it is possible to distinguish between three of these. The first system is a crude one of unrelenting warfare between two parties. That system is defended at the present moment in the United States, where a group of sociologists and trade union leaders maintain that the bitter struggle between the parties in itself produces a high standard of living and high efficiency. They claim that the European system of social responsibility creates conditions of stagnation, low wages and low productivity. They believe that a fierce struggle will create efficiency, effective man-hour saving devices and highly paid labour. If this system has any value at all, such a system can only exist in a country with an expanding economy, with a highly mobile labour force and with great natural resources. The second system is the system behind the Iron Curtain, a system of complete State control over labour and management, where no disputes are possible because the answer to every dispute is a slave camp. Such a system cannot be accepted by anyone who believes in human dignity and freedom. The third system is the one which occurs mostly in Europe, a system of negotiation; where this does not produce the right result there is the alternative of a panel solution by arbitration. If this is the right system at the present moment, there is no reason for complacency. While this system may be acceptable to management and to the trade union leaders, it may not be acceptable by the rank and file.

Management in Europe should not be content, said Dr. Stikker, with the negative task of preventing strikes. It should look for the positive task of increasing productivity. Here every individual manager has a part to play because industrial unrest is not always due to frustrated wage claims, although that may well be the reason for its origin. Management should not be on the alert only for discontent; it should strive to create an atmosphere where a man derives satisfaction from, and at the same time gets a little praise for, doing a good job. This idea of social responsibility is not new; but to put it into effect is another story. Management could not give a greater contribution to prosperity than by a universal acceptance and application of this principle of social responsibility. T. H. HAWKINS

DETERMINATION OF VITAMIN A IN NATURAL PRODUCTS AND IN MARGARINE

AT a joint meeting of the Oils and Fats Group of the Society of Chemical Industry, and of the Society of Public Analysts, held at Burlington House, London, on December 1, papers were read on the determination of vitamin A in natural products and in margarine.

Prof. R. A. Morton, in a communication with F. Bro-Rasmussen, recalled that for some years the unit of vitamin A activity was defined as that exhibited by 0·6 μgm. of the precursor, β-carotene. Vitamin A itself was later crystallized and its activity was found to be $3{\cdot}3 \times 10^6$ units per gm. The International Unit was re-defined as the activity of 0·3 μgm. of pure crystalline all-*trans* vitamin A or the equivalent weight of vitamin A acetate. Vitamin A is usually determined by the intensity of absorption at the maximum (near 325 mμ) in its ultra-violet absorption spectrum, and a conversion factor of 1,900 (see Table 1) has official sanction internationally as well as in pharmacopœias.

It was inevitable that the reference substance should be all-*trans* vitamin A (acetate), and indeed much of the demand for vitamin A, for example, for the fortification of margarine, is now being met by the synthetic all-*trans* acetate.

When vitamin A is determined by its ultra-violet absorption, the spectrophotometric measurements must be made on solutions in which vitamin A is responsible for a large proportion of the intensity of absorption in the region 300–350 mμ. This condition

Table 1. Vitamin A Alcohols

	All-*trans* Vitamin A_1	Neovitamin A_1	Vitamin A_2
Potency (I.U./gm.) × 10^6	3·33*	2·66[3]	1·33[4]
$\lambda_{max.}$ mμ in *cyclo*hexane	326	328	351
$E(1\%, 1\text{ cm.})$ at $\lambda_{max.}$	1,745[3]	1,650[4]	1,350[4,7]
$E(1\%, 1\text{ cm.})$ at 326 mμ	1,745	1,615	1,050
Conversion factor (that is, potency ÷ $E(1\%, 1\text{ cm.})$ at 326 mμ)	1,908	1,647	1,267

* By definition.

often requires that the vitamin should first be concentrated, for example, into an unsaponifiable fraction or into a chromatographic fraction; but manipulative losses may detract from the advantage gained by improved spectroscopic 'quality'.

The correction procedure of Morton and Stubbs[1] incorporated in official methods now in force is used for discounting 'irrelevant' absorption. The procedure makes it essential that the spectrophotometric properties of the material to be estimated shall be known with considerable accuracy; this condition is fully met in the case of all-*trans* vitamin A (see Cama, Collins and Morton[2]) and the correction procedure is indeed very successful for products containing synthetic vitamin A.

Natural products, however, such as fish liver oils, contain at least three (and possibly more than three) vitamin A-active substances, namely, all-*trans* vitamin A_1, neovitamin A_1 and vitamin A_2. The latter is generally a minor component (except in some fresh-water fish liver oils), but the variability of the ratio A_1/A_2 may be as troublesome to the analyst as that of the ratio of all-*trans* to neovitamin A.

Neovitamin A (the most important of several possible *cis*-isomers) and vitamin A_2 are ignored in the pharmacopœias, the revisers of which are rightly reluctant to take action which might turn out to be premature. The properties of vitamin A alcohols are illustrated in Table 1.

In order to display the problem, let it be assumed that in a concentrate (for example, from cod liver oil), for every molecule of A_2 there are eight of A_1, six as all-*trans* and two as neovitamin A_1. Using *cyclo*hexane as solvent, the intensity of absorption would be:

	$E(1\%, 1\text{ cm.})$ at 326 mμ
All-*trans* contribution, 6/9 of 1,745	= 1,163·3
Neovitamin A_1 contribution, 2/9 of 1,615	= 358·9
Vitamin A_2 contribution, 1/9 of 1,050	= 116·7
	1,638·9

The potency would be:

All-*trans* contribution, 6/9 of 3·33	= 2·22 × 10^6 u./gm.
Neovitamin A_1 contribution, 2/9 of 2·66	= 0·593 ,,
Vitamin A_2 contribution, 1/9 of 1·33	= 0·148 ,,
	2·961

and the overall conversion factor would be:

$$2{\cdot}961 \times 10^6/1{,}638{\cdot}9 = 1{,}807$$

The overall factor will fall as the proportion of neovitamin A_1 or vitamin A_2 increases, and will reach 1,687 with 30 per cent A_2, 30 per cent neo- and 40 per cent all-*trans* vitamin A_1.

If correction is made for irrelevant absorption, using three points on the curve for all-*trans* vitamin A_1, the neovitamin A contribution is reduced by 20 per cent (*cyclo*hexane) and that of vitamin A_2 by 90 per cent (that is, it is almost eliminated). For a mixture in which the proportions all-*trans*/neo-/A_2 are 70/21/9, it is known that by reason of a compensation in which over-correction of neovitamin A absorption matches the lower potency (2·66 instead of 3·33 × 10^6 u./gm.), the British Pharmacopœia and United States Pharmacopœia methods lead to much more trustworthy estimates of vitamin A_1 potency than might have been expected.

Three cod liver oils and two rich fish liver oils were tested at Liverpool using the British Pharmacopœia method and at Copenhagen using the chromatographic method described below. The degree of agreement was on the whole good. The Liverpool estimates of vitamin A_2 content were based on the colour test (antimony trichloride) intensity at 693 mμ, and were higher than those based on chromatographic separation of the vitamin.

The estimates of neovitamin A content using the Robeson and Baxter[8] method, which rests on different rates of adduct formation with maleic anhydride, showed only moderately good agreement with the results of chromatography.

A paper on the chromatographic separation of vitamin A-active compounds in cod liver oil by F. Bro-Rasmussen, W. Hjarde and Olga Porotnikoff from the State Vitamin Laboratory, Copenhagen, was read by Mr. G. A. J. Pitt, of the University of Liverpool.

The adsorbent is dicalcium phosphate activated as described by L. A. Moore[9]. Using the unsaponifiable fraction from 3 gm. of a cod liver oil (about 3,000 I.U.) and a chromatographic column 50 cm. long and 3 cm. in diameter, the vitamin A was carried down the column by means of light petroleum. Development of the chromatogram was completed by the use of 600 ml. of light petroleum-ether (16 : 1 v/v) collected in 15-ml. portions from the first appearance in the eluate of material giving a blue colour with antimony trichloride. The material collected in the first 225 ml. was almost entirely neovitamin A, and the all-*trans* vitamin A_1 was completely eluted in the next 225 ml., with vitamin A_2 following in the next 150 ml. The separation was clean and the spectra of 15-ml. portions at the 'peak' elution of each vitamin A-active component were precisely characteristic and agreed with published information.

The recommended procedure is to take enough cod liver oil to yield about 1,600 I.U. vitamin A activity, and to chromatograph the unsaponifiable fraction on a 10-cm. column of activated dicalcium phosphate. A good deal of material responsible for irrelevant absorption can be eluted before any vitamin A; this is discarded and the total vitamin A-active material is then eluted with light petroleum-ether. The solvent is removed and the residue dissolved in absolute ethanol, and the ultra-violet absorption is measured at 310, 325 and 350 mμ. The value of $E(1\%, 1\text{ cm.})$ at 325 mμ is taken as a measure of total vitamin A concentration. The unsaponifiable matter is then chromatographed on a long column (60 cm. × 1·5 cm.). The eluents (light petroleum–ether, 400 ml., 16 : 1 v/v, and 400 ml., 12 : 1 v/v) are collected in 10-ml. portions and the values of E at 325 mμ are measured. Three maxima are shown when E is plotted for successive 10-ml. portions, and it is easy from the graph to combine the portions containing neovitamin A_1, all-*trans* vitamin A_1 and finally vitamin A_2. The chromatography results in recovery of about 90 per cent of the absorption at 325 mμ

obtained after the simple elimination of irrelevant absorption using the short column. It is assumed that the loss of 10 per cent is not selective and the observed values of E at 325 mμ for the three vitamin A-active components are accordingly scaled up. The all-*trans* vitamin A_1 absorption (in E(1 %, 1 cm.) 325 mμ) multiplied by 1,800 gives its contribution in international units; similarly, the neovitamin A_1 absorption at 325 mμ is multiplied by 1,610 and that of vitamin A_2 by 1,060 (solvent is ethanol).

The British Pharmacopœia method is simple and fortunately gives trustworthy results for the total vitamin A_1 activity. The vitamin A_2 contribution may be determined separately.

J. Walter Lord and Miss P. M. Bradley submitted a method for the spectrophotometric estimation of vitamin A in margarine. The amount of vitamin A (*c.* 30 I.U./gm.) is not great and the unsaponifiable fraction shows a good deal of irrelevant absorption derived from the constituents of the fat or from added carotenoids or dyes. Boldingh and Drost[10] described an effective procedure for obtaining from margarine a fraction practically free from irrelevant ultra-violet absorption, and the method has received official recognition[11]. It depends on chromatography using two specially activated adsorbents in tandem columns, and although simplifications of the method have been suggested (for example, by Rosner and Kan[12]) it is still necessary for the analyst to undertake two preparations of specially activated alumina.

The modified method of Lord and Bradley is more convenient. It is based on a simple chromatography using bone meal, an adsorbent advocated by Mann[13] and used by Goodwin and Morton[14] for separating carotene and vitamin A unsaponifiable extracts from margarine. Commercial defatted bone meal is suitable if it passes an 80-line sieve but is retained by a 170-line sieve. These limits are not critical, but particles of this size allow a reasonable rate of flow of solution and also permit absorbing impurities to be separated from vitamin A.

The unsaponifiable fraction from 10 gm. of margarine is dissolved in petrol (boiling point, 80–100°) and transferred to a column of bone meal (9 in. × ⅝ in.) already full of petrol. The yellow dye or the added carotene can be washed through the column by means of petrol (slight air-pressure is useful). When the eluate is no longer coloured, the solvent is changed to petrol containing ether (16 per cent v/v) and the eluate is then collected in 5-ml. portions. The tubes containing vitamin A are identified by using the Carr–Price test on very small portions of eluate. Aliquots are withdrawn and united for spectrophotometric measurements at 315, 325 and 335 mμ.

Vitamin A alcohol could be recovered from the column without loss or spectroscopic impairment. When it was added to the unsaponifiable fraction from unvitaminized margarine, the average 'recovery' was 108 per cent, in close agreement with experience of the official method (compare Morgareidge[15]). The high 'recovery' is due to the presence of material exhibiting irrelevant absorption. The reading at 315 mμ is always somewhat greater than that of 335 mμ, but the irrelevant absorption at 335 mμ is very small. The difference between readings at 315 mμ and 335 mμ gives a good approximation to the irrelevant absorption at 325 mμ. When this correction is applied, 'recovery' is nearer 100 per cent. Comparison of the results of the new method and the official method showed excellent agreement, and many workers may find the simplicity of the bone meal method attractive.

A brisk discussion followed. The possibility that the neovitamin A_1/all-*trans* ratio might be altered by saponification was mentioned. The constancy of bone meal was also queried; however, this adsorbent is reproducible and can be used several times.

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NATIONAL RESEARCH COUNCIL OF CANADA

ANNUAL REPORT FOR 1953–54

THE thirty-seventh annual report of the National Research Council of Canada* covers the year ended March 1954, and, following the pattern of the last report, includes, besides the president's report and the financial statement, the annual report of Canadian Patents and Development, Ltd., for the year ended March 31, 1954. Pilot-plant operations on the Cambron process for the direct oxidation of ethylene were discontinued; but the pilot plant is being maintained in a standby condition, and the Applied Chemistry Division of the National Research Council has carried out further research on reactors for the Company. The Company has also established a Development and Promotion Section to encourage contact with industry and the use of inventions controlled by the Company.

The president's report records that during 1953 the National Research Council provided two million dollars in 420 awards and 230 scholarships and fellowships for fundamental research in the universities. Its scientific staff numbered 535, with 679 non-professional technical personnel and 741 others employed in services, maintenance and administration, as well as some eighty post-doctorate Fellows. Technical inquiries from Canadian industries are now running at the rate of eight thousand a year, and already some eighteen hundred science graduates have gained advanced training in research by the Council's extra-mural support of fundamental research. New buildings for the Divisions of Applied Chemistry, Building Research and Radio and Electrical Engineering were completed during the year, and additions made to the thermodynamics building.

In the Division of Applied Biology, the industrial possibilities of the improved citric acid fermentation process as an outlet for Canadian sugar-beet molasses

* Thirty-seventh Annual Report of the National Research Council of Canada, 1953–54, including the Annual Report of Canadian Patents and Development, Limited. (N.R.C. No. 3286.) Pp. 50. (Ottawa: National Research Council, 1954.)

are now being tested in the pilot plant. Research on dairy products has indicated the protective action of dissolved lactose on milk proteins during frozen storage, while electron microscope studies, in collaboration with the Department of Agriculture, have established the way in which a virus attacks bacterial disease of crop plants and the size and shape of the virus. The role of lipoxidase, an enzyme occurring in plant tissues, in the oxidation of fats is being evaluated, and radioactive tracer techniques have shown that in detached sugar-beet leaves a ten-second photosynthetic period yields significant amounts of such complex molecules as cellulose, as well as simple sugars and amino-acids.

In the Prairie Regional Laboratory, Saskatoon, the major effort is being concentrated on production from agricultural wastes and surpluses of such substances as enzymes, antibiotics, vitamins for feed supplementation, and other compounds obtainable only by biological synthesis. Current investigations include studies on the physiology and biochemistry of living plants, the mechanism of fermentation processes using sugar or carbohydrate nutrients, and the chemistry of such plant materials as starches, sugars, cellulose, lignin, proteins, fats and oils. The process for separating prime starch and vital gluten from wheat flour has been improved, and trials of the new fluidized-bed dryer indicate that wheat can be dried at air temperatures greatly in excess of 180° F. (82·2° C.) without damage or loss in baking quality. The Maritime Regional Laboratory, Halifax, has been concerned largely with fundamental and applied aspects of the utilization of seaweed. Rockweed appears to be a less suitable source of alginate than kelp. The distribution of amino-acids in the proteins of several species of seaweed has been determined, the chemical structure of fucoidin from rockweed clarified by isolation of a new crystalline disaccharide, maritol, and carrageenin from Irish moss fractionated into a polymer which appears to be responsible for the high viscosity of the sol fraction and another governing gel strength.

In the Division of Pure Chemistry, the red pigment uroporphyrin I has been synthesized and its structure confirmed, while it has also been shown that the two alkaloids, hordenine and gramine, generated in sprouting barley, are formed from amino-acids, the first from tyrosine, and the second from tryptophan. Further information about the internal structure of the hydrogen peroxide molecule has been obtained in low-temperature measurements by the Low Temperature Colorimetry Section in collaboration with workers at Laval University, and the thermodynamic functions of hydrogen peroxide gas have been calculated up to 1,200° C. A thermal diffusion column built by the Section on Physical Properties of Liquids and Gases for the separation of krypton isotopes gave a krypton-84 containing only 2·4 per cent of krypton-86.

In the Division of Applied Chemistry, besides work on the catalytic oxidation of ethylene, much effort has been spent on the evaluation of silver catalysts for the process. In collaboration with the Canadian Research Institute of Launderers and Cleaners, a study of the sorption of surface-active agents by textile fibres was completed, and studies were being made of the factors affecting the soiling characteristics of textile fibres, of the microbiological and ultra-violet breakdown of cellulosic fibres, and of methods of measuring damage in the newer synthetic fibres. The study of inhibitors for the corrosion of metals in water and in glycol anti-freeze systems continued, as well as development work on the production of high-purity single crystals of germanium. A study of the decomposition of the polymerizing and blowing agent 'Porophor *N*' was completed, and work was started on the oxidation of polyvinyl alcohol by Fenton's reagent.

In the Division of Physics a universal detector for atomic and molecular beams has been developed which has already been used in the study of silver, gold and boron. The presence of free aldehyde radicals when acetaldehyde, formaldehyde or glyoxal is irradiated by ultra-violet light has now been established, and the Spectroscopy Laboratory has also resolved the Raman spectra of benzene vapour and obtained precise values for the geometrical dimensions of the benzene molecule. Important information about the nature of the primary cosmic radiation and on nuclear reactions caused by cosmic rays has been obtained from a microscopic study of plates exposed in balloons at altitudes of more than 100,000 ft., while, in a theoretical evaluation of other experimental data on the upper atmosphere, the variation of the dissociation of molecular oxygen into atoms with height has been derived and the variation of the electron concentration in the *E*-layer calculated. Apparatus is being set up to study the electrical and other properties of metals under pressures up to 10,000 atmospheres. In the Applied Physics Branch, studies by the Acoustics Laboratory indicate that ultrasonics are ineffective as repellents for ducks and ring-billed gulls. An improved ear defender has been developed to the prototype stage. Experiments were in progress on the determination of the gravity constant by direct observations on a falling body using modern optical and electronic developments. A new technique has been developed which increases the precision and convenience of interferometry in measuring length, and the extension of existing ground control points by mathematical computation from measurements on air photographs was also being examined in co-operation with the University of Toronto. A set of carbon-filament lamps for photometric standards has been calibrated using a small refractory tube immersed in molten platinum; and the amount of radiation in the beam emitted by cobalt beam therapy units was being measured in the Radiology Laboratory. A photographic 'camera calibrator' has been constructed for air cameras and put into use.

The dedication on October 23, 1953, of the new Building Research Centre, which is believed to be the first building of its kind designed to serve the general needs of building research, was the culmination of the first three-day Conference on Building Research to be held in Canada. The new building does not include accommodation for the Division's work on fire research, which has progressed steadily during the year, in relation both to fire losses and to civil defence. The Division continues to operate Canada's only sound chamber for acoustical research in relation to buildings, while important results on the reflective insulation of walls in cold weather have been obtained by the Division in the Prairie Regional Laboratory at Saskatoon. Work on the revision of the national building code continued, and the Division broadened its work in the field of technical housing research.

The Division of Mechanical Engineering continued its investigations of means of protecting aircraft and engines against de-icing, while in aerodynamics the

emphasis has shifted towards the transonic and supersonic speed-range. In hydrodynamics the St. Lawrence Seaway project became a major interest, and a 1/30 scale model of one of the navigation locks was being used for determining the effect of the spacing of the filling ports and valve-opening schedules upon the rate of filling of the lock and upon variations in the water surface. Gas turbines absorbed the major effort in thermodynamics, and a system of thrust boosting for aircraft jet engines by exhaust reheat was being developed in which most of the additional fuel is injected before the turbine. The influence of fuel composition, antioxidants, drum materials and other factors on the rate of deterioration of fuels in storage was being investigated, and a theoretical analysis of the stiffness and optimum weight-stiffness of tubes with inclined ribs showed that true optimum weight-bending stiffness configurations exist in the conventional wing range of aircraft structures, but that for torsion the optimum condition is beyond applicable limits.

Much of the work of the Radio and Electrical Engineering Division has continued to be on defence projects, but a microwave position-fixing system for vessels engaged in offshore survey operations has been developed and constructed, as well as a microwave link for remote control of isolated fog-alarm stations, and a wired-television link with a remotely controlled camera mounted in a submersible cylinder which permits surface operators to study aquatic flora and fauna, bottom details, wharf pilings, hulls, etc., to depths of a hundred feet. A new merchant-marine radar set with improved performance in both short-range definition and long-range detection has also been developed, while studies of semiconductors have led to an understanding of the operation of a crystal rectifier at high voltage. An improved antenna has been developed for use with domestic television receivers as well as a highly accurate frequency-measuring attachment for radio receivers and also a combined electro-phono-cardiograph which presents simultaneously on the screen of a cathode-ray oscillograph the wave forms of the electrical impulses from the heart together with those of the sounds due to heart motion. A new type of mass spectrometer, the 'omegatron', for determining the constituents of gas mixtures, has been designed and built.

Most of the 136 grants-in-aid made by the Division of Medical Research were in the basic medical sciences, about two-thirds being for a continuation of previous studies. Some grants for experimental studies in pathology and surgery indicate an interest in the cause and nature of disease and in physical methods of treatment.

EXPERIMENTAL INVESTIGATION OF LEAF FORMATION, SYMMETRY AND ORIENTATION IN FERNS

By Prof. C. W. WARDLAW

Department of Cryptogamic Botany, University of Manchester

INVESTIGATIONS of the inception and development of leaf primordia in *Dryopteris austriaca* have yielded the following information. (Primordia are referred to as P_1, P_2, P_3, etc., P_1 being the youngest visible primordium; I_1 indicates the site of the next primordium to be formed and I_2 the next after that. The tetrahedral cell at the tip or summit of the shoot and its recently formed segments are referred to as the 'apical cell group'):

(i) Leaf primordia are always formed on an apical meristem.

(ii) A leaf primordium typically originates near the base of the apical cone. It consists of a circular to elliptical group of the distinctive, superficial prism-shaped cells of the apical meristem, which grows out, forming a low mound of tissue; the small-celled tissue within is also in a state of active division.

(iii) A young primordium, situated between and above two older ones, occupies only a small part of the free surface of the apical cone.

(iv) On further development, an approximately central, superficial cell of the primordium now becomes much enlarged. During this process, this 'leaf apical cell' acquires its characteristic 'two-sided' shape, its orientation being such that the segments produced by its division lie in the tangential plane. These give rise to the marginal meristems from which the tissues of the primordium are formed.

(v) The alignment of the leaf apical cell and of its partition walls at cell division is thus at right-angles to the principal direction of growth in the subtending apical cone, that is, the tangential direction; and it may well be that the shape and disposition of the leaf apical cell are directly attributable to the relatively large tangential component of growth in the leaf site. Once the two-sided apical cell has been established, the foliar nature of the primordium is irreversibly determined.

(vi) In relation to the position in which a leaf primordium originates, that is, on the side of a cone, growth on its abaxial side is more rapid than on its adaxial side; and this difference soon becomes accentuated as the primordium passes into the actively growing and rapidly widening subapical region of the shoot (Fig. 1). It thus appears that the

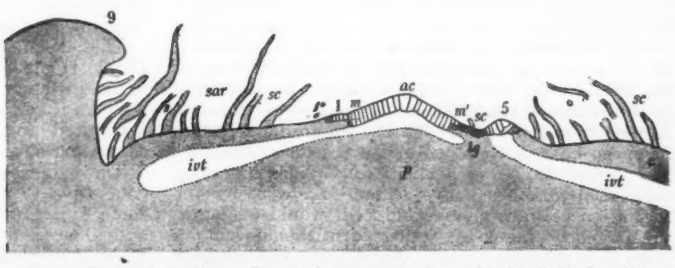

Fig. 1. *Dryopteris austriaca*; the apical cone as seen in median longitudinal section, traversing the youngest visible primordium (1) and older ones (5, 9). The apical cell, *ac*, and the distinctive prism-shaped cells of the apical meristem *m–m'* are shown. *sc*, scale; *c*, cortex; *p*, pith; *ivt*, incipient vascular tissue; *lg*, leaf-gap; *sar*, sub-apical region. (Semi-diagrammatic × 30)

orientation, dorsiventral symmetry and shape of a developing primordium may be referred to the growth activity of the region of the shoot apex in which it originates and to the disposition and activity of its own apical and marginal meristems.

(vii) While a primordium still forms part of the apical cone, its growth is relatively slow; but once it is in the subapical region, its growth and morphological development are rapid. The sooner a primordium comes to occupy a subapical position, that is, as a result of the growth of the shoot apex, the more rapid will be its enlargement and morphological elaboration. Thus, a P_3 primordium on a small apex of low phyllotaxis is larger and more elaborate than a P_3 on a large apex of high phyllotaxis.

(viii) The actual inception of leaf primordia is an obscure and complex phenomenon. In ferns, the indications are that a primordium is formed at a growth centre, that is, a locus of special metabolism. The position of this centre is apparently controlled by the apical cell group at the summit of the shoot and by the two adjacent primordia of the top whorl. The growth centre consists of a circular group of seven to nine meristem cells in which we may suppose there is an accumulation of the substances that determine the outgrowth of a lateral organ.

On the basis of experimental observations, I have already attempted[1] to relate leaf symmetry and orientation in ferns to the position in which the primordium originates, and to possible inhibitive effects proceeding basipetally from the apical cell group. Thus it was shown that if the I_1 position is isolated from the upper part of the apical meristem by a deep tangential incision, a bud, and not a leaf, is formed. In general terms it was thought that, as a result of this operation, inhibitive effects from the apical cell group would be precluded, and a levelling up of the growth-rates on the adaxial and abaxial sides of the primordium might take place. If so, the development of a radially symmetrical organ, that is, a shoot bud, might be expected. Cutter[2] has since shown that if P_1 and P_2 are similarly isolated before the characteristic two-sided initial cell has been formed, they, too, can be transformed into buds; and Wardlaw and Cutter[3] have shown that the prevascular tissue, which immediately underlies the prism-shaped cells of the meristem, is important in these several morphogenetic developments.

In some recent experiments an attempt has been made to ascertain whether the dorsiventral symmetry and orientation of leaf primordia can be attributed: (*a*) to a specific localized effect, on the adaxial side of the primordium, of an inhibiting substance proceeding from the apical cell group; or (*b*) to the regulated growth which is characteristic of the intact shoot apex as a whole. In relation to (*b*), it may be noted that there is a steady acceleration in the rate of growth from the apex to the base of the apical cone, and a rapid acceleration of growth in the region of transition from the base of the cone to the sub-apical region (Fig. 1). Primordia originate near the base of the cone and are soon affected by this active region of transition. Wide and deep tangential incisions above P_1 and I_1, whereby the formation of buds can be induced, would evidently preclude (*a*) and cause serious disturbances to (*b*). Here it is relevant to note that when bud formation is induced in a leaf site, for example, at I_1, or by the transformation of a leaf primordium, for example, P_1, the bud not only quickly develops a large apical meristem but also shows strong growth on its adaxial side.

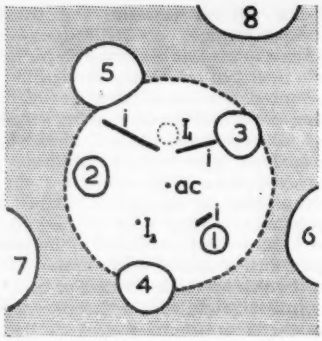

Fig. 2. *Dryopteris austriaca*. Apex as seen from above, showing leaf primordia 1–8 and the positions of I_1, the next primordium to be formed, I_2, the next after I_1, and the apical cell *ac*. A small deep incision, *i*, has been made on the adaxial side of P_1. Two wide and deep tangential incisions, *i*, *i*, have been made above I_1 so as to leave a 'bridge' of intact tissue between the primordium site and the apical cell. The sub-apical region is stippled

Of a considerable and varied series of new surgical experiments which have now been carried out, the two most directly relevant to the problems of leaf and bud formation are illustrated diagrammatically in Fig. 2. In one series, small deep tangential incisions, severing the incipient vascular tissue, were made immediately above I_1, I_2, P_1 and P_2. If dorsiventrality in a primordium is due to a limitation of the growth-rate on its adaxial side, that is, as a result of the basipetal movement of a growth-regulating substance from the apical cell group, some bud formation might be expected in this experiment. In the other series, two deep and extensive tangential incisions were made just above a primordium (or primordium site), so as to leave a 'bridge' of intact tissue between it and the apical cell group. If dorsiventrality is mainly due to a localized (adaxial) inhibitional effect proceeding from the apical cell group, then leaves should still be formed; but if it is a result of the regulated growth of the apex as a whole (or of the sector in which the primordium is situated), then, in relation to the extensive restriction of both the acropetal and basipetal movement of metabolic substances by the tangential incisions, and the consequential radical disturbance of the normal distribution of growth in the apical cone, some bud formation might well be expected.

The results of these two experiments are set out in Tables 1 and 2, the records relating to specimens in which the apical cell group remained intact and quite undamaged. (These experiments are of some delicacy and not easy to perform successfully.)

The evidence from the first set of experiments (Table 1) is conclusive: small adaxial incisions have in no instance resulted in bud formation. It thus appears that the dorsiventrality of leaves cannot be attributed to the localized action of a growth-regulating substance on the developing primordium.

The evidence from the second series, though less conclusive, is none the less important. In at least some apices (actually 25 per cent of all primordia and 40 per cent of I_1's), bud formation can be induced when the apical cell is undamaged and when intact tissue extends between it and the primordium (Fig. 3). In those apices in which buds were formed, the experimental region was marked by very con-

Table 1. Effect of Small Adaxial Incisions

Primordium	Leaf formed	Bud formed	No development
I_3	2	—	—
I_4	6	—	2
P_1	9	—	1
P_2	3	—	—
Total	20	0	3

Note. In other specimens, in which the shoot apex had accidentally been slightly damaged, 13 leaves and 6 buds were obtained.

Table 2. Tangential Incisions with Intact Bridge

Primordium	Leaf formed	Bud formed	No development
I_3	3	—	—
I_4	7	5	3
P_1	9	2	1
P_2	1	1	—
Total	20	8	4

Note. Where the 'bridge' had been eliminated, that is, by the two incisions joining up, or where the shoot apex had been damaged, even very slightly, buds were usually formed. Where the 'bridge' was wide, leaves were usually obtained, though occasionally a bud was formed.

spicuous growth activity and the buds were of large size (Fig. 3). Late-season apices, which were relatively inactive, typically yielded leaves.

Where buds were obtained, as in Fig. 3, microtome sections showed that the bud was in vascular continuity with the parent shoot in the region of the 'bridge'.

In the light of these experimental results, to what factors and relationships may the organization of the fern apex and its orderly morphogenetic activity be attributed ?

There is considerable support for the view that the apical cell group is a region of special metabolism, as

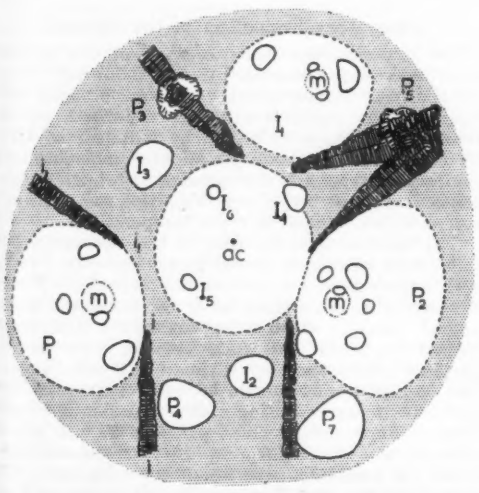

Fig. 3. *Dryopteris austriaca*. Apex, as seen from above, showing the large buds which have been induced in the I_3, P_1 and P_2 positions when these positions were partially isolated from the shoot apical cell by two wide tangential incisions. In each instance a 'bridge' of intact tissue was present on the adaxial side of the primordium. *ac*, position of the apical cell of the main apex. P_1–P_7, primordia present at the beginning of the experiment, P_1 and P_2 having been transformed into large buds. The locus of I_3 has also developed into a large bud. i_3–i'_3,i_4, tangential incisions. I_5–I_6, new leaf primordia formed during the course of the experiment. *m*, apical meristem of induced buds. The broken lines indicate approximately the bases of the main apex and of the buds. (Diagrammatic camera lucida tracing, × 15)

is also each growth centre which may become a leaf, or, if subjected to experimental treatment, a bud. Products of the metabolism of the apical cell group, moving basipetally by way of the prevascular tissue, may exercise a regulative effect on the growth of the apical and sub-apical regions. Thus, in the upper part of the apex, where the concentration of the growth-regulating substance will be high, the rate of growth of the meristem cells may be kept low ; but lower down, and in the region of transition to the sub-apical region, where the concentration of the growth-regulating substance will be much lower, growth may be promoted. This hypothetical substance, which might be an auxin or hormone, or a precursor of one or other of these, is likely to be essential in some way to protein synthesis, as Skoog[4] has recently suggested. An important feature of this conception is that the substance will produce its organizing and morphogenetic effects by the way it affects the growth of individual cells, each of which will react in a characteristic way according to its physiological state, rather than by its action on primordia as such.

An alternative view might take the form that the apical cell group is not a locus of special metabolism, the organization of the apex being due to competition among its constituent cells for the nutrients involved in growth. As these nutrients move acropetally from the older regions below, with differential utilization of the several substances at different levels *en route*, the supply will diminish progressively and change qualitatively as the shoot tip is approached.

The most satisfying explanation, however, probably lies in a combination of the two views. Thus destruction or isolation of the shoot tip would simultaneously remove both its regulative and competitive activities. In the 'bridge' experiment described above, the two wide tangential cuts go a long way towards isolating the shoot tip, and, as we have seen, marked growth activity may be induced on the adaxial side of primordia and buds may be formed. On the other hand, as even a cursory inspection will show, a small incision above a primordium will do little to modify the normal movement of metabolites. As rapid wound-healing, with formation of parenchyma and an outgrowth of scales, takes place at the injured tip and in proximity to incisions, it is evident that both the quantity and quality of the nutrients being drawn upwards are different from those normally utilized in the growth of meristem cells. Scale and parenchyma formation, indeed, are characteristic of the normal growth developments on the abaxial side of actively developing primordia. Furthermore, in apices with a damaged tip, young primordia, already determined as leaves, may be observed facing and curving outwards instead of inwards, in relation to the high rate of growth on the adaxial side.

In conclusion, it may be noted that in the ferns the apical cell is the focal point in the distal meristem and is essential for the continuing growth of the shoot. It may also be regarded as the ultimate determiner of the orientation and symmetry of leaf primordia. But such effects are apparently not produced by its direct action but are mediated through the organization and physiological activity of the apex as a whole.

[1] Wardlaw, C. W., *Growth* (Supp.), **13**, 93 (1949).
[2] Cutter, E. G., *Nature*, **173**, 440 (1954).
[3] Wardlaw, C. W., and Cutter, E. G., *Nature*, **174**, 734 (1954).
[4] Skoog, F., Brookhaven Symp. Biology, **6**, 1 (1954).

A NEW ABSOLUTE HYGROMETER OF HIGH ACCURACY

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THE history of hygrometry, especially during the past few decades, has been characterized by a continual searching for new methods which do not suffer from the shortcomings of inaccuracy, slow response or general inconvenience encountered with the classical methods. Probably the most important developments which have resulted are the electrolytic method of Dunmore[1] and the 'Dewcel' described by Hickes[2], both of which have been successfully applied in particular fields. These methods involve the construction of relatively complex and expensive sensitive elements.

Dunmore's elements, and somewhat similar types developed since, suffer from the disadvantage that their humidity – resistance relationship is empirical and subject to change with time and especially with exposure to extreme conditions. The 'Dewcel' method is limited in accuracy by the fact that the electrode wires occupy an appreciable fraction of the surface area of an element, and by changes which occur in the electrolytic medium. The error of a 'Dewcel' can be determined only by comparison with an independent hygrometer.

No convenient method of hygrometry has yet been reported which can approach the accuracy of the dew-point method.

The dew-point method itself suffers from a number of disadvantages, notably that the visual instruments are slow and tedious to use and that the presence of contamination on the dew-condensing surface can give rise to unsuspected errors. On account of the way in which condensation and evaporation occur, and because of the operator's desire to achieve the best accuracy, the tendency, both with visual instruments and with automatic instruments in which the condensing surface is examined by photoelectric or equivalent means, is to work with the smallest possible quantity of dew. The effects of contamination will then be greatest. In fact, during condensation on a polished surface, the amount of light scattered by the deposit increases only during the earliest stages, associated, in most cases, with the dissolving of minute quantities of soluble matter and the dilution of the consequent solution. Only an instrument in which equilibrium can be established between pure phases can yield results which are independent of the mechanism of the phase change and hence which are accurately reproducible.

The method to be described here is absolute in the same sense as the dew-point method, and is more accurate and more amenable to instrumentation.

The principle is simple and is derived from the fact that water vapour is taken up by the surface of a water-soluble crystal if the water-vapour pressure is greater than the vapour pressure of a saturated solution of the crystalline substance at the temperature of the crystal surface. This gives rise to a layer of saturated solution on the surface of the crystal, and for any soluble crystal surrounded by moist gas of constant composition a critical temperature exists at which the surface layer is in equilibrium with its surroundings. If the crystal is ionic, the presence of this layer, as well as changes in its thickness, can readily be detected by electrical methods. By raising or lowering the temperature of the system the critical temperature can be determined with great precision, since the electrical resistance of the layer, which is too thin to flow, will remain constant at that temperature. The partial pressure of the water vapour in the gas surrounding the crystal can then be deduced from a knowledge of the vapour pressure of the saturated solution of the salt as a function of temperature.

If a temperature which is slightly higher than the critical value is maintained, the electrical resistance between suitable electrodes making contact with the crystal surface will increase steadily until a very high value is reached which is related to the adsorption of water at the surface. If a temperature which is slightly lower than the critical value is maintained, the resistance will decrease steadily until the ionic substance is excessively dissolved. If the surface of a pure ionic crystal is clean, the actual value of the electrical resistance, the constancy of which indicates that the critical temperature has been established, may be chosen arbitrarily within a very wide range. For example, using a crystal of potassium chloride of cubic form, it has been found that for resistances measured between opposite faces of the crystal, of less than 0·05 to more than 5 megohms, the equilibrium temperature is constant within the accuracy of the best measurements made, namely, ± 0·01 deg. C.

Laboratory Evaluation of the Method

The practicability and accuracy of the method were first demonstrated by the following simple experiment. Atmospheric air was brought into water-vapour equilibrium with saturated sodium thiosulphate ('hypo') solution by bubbling it slowly through a tube containing a slightly undersaturated solution of 'hypo' and then passing it through a tower containing moist 'hypo' crystals; this was done in a stirred Dewar vessel at room temperature.

The air was then brought to the temperature of the stirred water in a second Dewar vessel by passing it through a glass coil immersed in the water. Thence it passed through a glass tube, also immersed in the second vessel, in which an approximately cubic single crystal of 'hypo' was held between two parallel graphite plates each approximately 2 mm. square. The electrical conductance between the crystal supports was measured using a direct-reading electronic unit of simple design which passed a 50 c./s. alternating current of about 5 μamp. between the electrodes when the resistance was about 0·5 megohm. The sensitivity was such that a resistance change of 1 per cent was easily detected.

By adding a few drops of either warm or cool water to the Dewar vessel containing the crystal unit, the temperatures in the flasks, which were measured with mercury-in-glass thermometers, could be equalized at approximately room temperature or caused to differ slightly either way. By interchanging the thermometers during an experiment, their separate calibration was rendered unnecessary.

Using the criterion that the resistance should be constant at some value in the range of 0·5–2 megohms, it was found that the temperatures could be equalized repeatedly as accurately as the thermometers could be read. Since the thermometers were similar and were divided to 0·05 deg. C., temperature equality to ± 0·01 deg. was therefore proved, thus establishing that the principle could serve as a basis for precise hygrometry.

Practical Form of the Hygrometer

A satisfactory form of the hygrometer is a small isothermal metal enclosure, about an inch long and an inch in diameter, in which a suitable ionic crystal is mounted on two chemically inert electrodes. The gas, the humidity of which is to be measured, is allowed to fill the enclosed space, which is cooled or heated as the case may require until the critical temperature is reached. If the gas is to be passed continuously through the enclosure, as will often be the case, it must be brought to the temperature of the enveloping metal before it is admitted. This may be achieved by first passing the gas through channels cut in the piece of metal or through an attached coil of metal tube.

The enclosure may be cooled by the passage of a refrigerant through appropriate channels. Carbon dioxide expanded at a small needle valve from cylinder pressure to atmospheric pressure may be used as a clean and easily regulated refrigerant. Heat may be provided electrically using a resistance winding of insulated wire wound directly on the metal. For very rapid response and for accuracy it is an advantage to measure the temperature of the metal enclosure with a resistance thermometer wound directly on to it or with a directly attached thermocouple.

The crystalline substance should be in the form of a single crystal or a transparent group of crystals; a group containing many fissures will slowly take up or liberate relatively large amounts of water. Crystals suitable for most purposes include potassium sulphate, sodium chloride, calcium chloride and lithium chloride, which possess equilibrium relative humidities of approximately 99, 76, 30 and 15 per cent, respectively. With potassium sulphate, for example, cooling will generally be necessary, whereas with lithium chloride heating is necessary except for relative humidities less than about 15 per cent, reckoned at ambient temperature. Although used for convenience in the initial experiments, sodium thiosulphate is not an ideal choice since it reacts sensitively with acid vapour and even carbon dioxide.

For manual operation the conductivity may be indicated directly on a deflecting instrument. For automatic operation the resistance of the crystal may be made, by electronic means, to govern the heating or cooling of the metal enclosure. Any such automatic system contains a perfect integrating link on account of the condensation process and must, therefore, give the true equilibrium temperature; however, the design must ensure that, for the maximum amplification consistent with stability, the response of the system is sufficiently rapid.

A hygrometer constructed in accordance with the above principles has been used with crystals of a number of salts. Experience with this instrument has shown that the method is reliable, accurate and rapid. When the equilibrium temperature is already known approximately, the time required to obtain a balance to ± 0·01 deg. C. is about one minute. The vapour pressures of saturated salt solutions are, however, not in general known at present with an accuracy higher than the equivalent of ± 0·1 deg. It should be mentioned that an accuracy of ± 0·01 deg., corresponding approximately to ± 0·1 per cent relative humidity, can be utilized fully only when the departure of the behaviour of a mixture of air and water vapour from the laws for a perfect gas mixture is taken into account.

Surface contamination of the crystal has not been found to be a serious problem. If present, it can readily be detected and its effect on the measurement eliminated by observing the balance temperatures for two widely different values of the resistance of the crystal unit and extrapolating to zero resistance. Soluble surface contamination which has not originated from impurities in the crystal substance is easily removed with water.

In some cases small jumps in the resistance, which probably resulted from electrode effects, have been observed. Any effects due to electrode phenomena can be eliminated by using four contacts on the crystal, representing current and potential connexions, or by using high-frequency methods with two electrodes spaced from the crystal. For most purposes the use of such methods is unlikely to be necessary.

Applications

The method provides a convenient substitute for the dew-point hygrometer. It is more accurate and more amenable to instrumentation. In contrast with the dew-point method, it allows accidental contamination of the surface to be detected easily. It is readily applicable to measurements on gases at very high pressures. With a crystal of calcium chloride, the useful range is continuous down to −55° C. Provided that the gas reaching the hygrometer is of constant composition and that the crystal is reasonably pure and is held by clean, well-formed electrodes, the ultimate accuracy is probably determined by the limitations of precise thermometry.

The instrument obviously provides a powerful tool for the accurate measurement of the vapour pressures of saturated salt solutions as a function of temperature. It is proposed to use as a standard substance potassium sulphate, the saturated solution of which provides a relative humidity of about 99 per cent, and work is in progress to determine accurately the vapour pressure – temperature relationship of a saturated solution of this substance relative to the vapour pressure of water. It is intended then to determine the vapour pressure curves for a number of stable salts, using each in turn for the hygrometer crystal element.

The method will be used for providing the standard of reference for the testing of hygrometers at the National Standards Laboratory in Sydney. Work is at present in progress on a rapid automatic instrument to be used as the humidity-sensitive unit for the accurate control of atmospheres in researches on biological materials in other laboratories of the Organization.

A detailed account of the hygrometer will be published elsewhere. I wish to acknowledge the work of Mr. W. van Peer in constructing the electronic resistance-measuring unit and in assisting with the experiments.

[1] Dunmore, F. W., *U.S. Nat. Bur. Stand. J. Res.*, **20**, 723 (1938); **23**, 701 (1939).

[2] Hickes, W. F., *Refrig. Eng.*, **54**, 351 (1947).

LETTERS TO THE EDITORS

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Specificity of Creatine Phosphokinase

Some of the properties of the enzyme creatine phosphokinase have recently been described[1]; but no experiments were reported on the activity of the enzyme with substrates other than adenosine triphosphate, adenosine diphosphate, phosphocreatine and creatine. Such experiments are in progress and will be reported in due course. A recent publication by Armstrong[2], in which it was shown that the administration of N-ethylglycocyamine (negmine) was followed by the urinary excretion of N-ethylglycocyamidine (negmidine), suggested that a phosphorylation reaction may have been involved. It was therefore of interest to determine whether negmine could be phosphorylated by the creatine phosphokinase system.

Some experiments have been carried out with a system similar to that already described[1] for the reaction:

$$\text{ATP} + \text{creatine} \rightarrow \text{PC} + \text{ADP},$$

but differing in that negmine was substituted for creatine and the temperature was controlled at 30°. The course of the reaction was followed by removal of samples at various time-intervals after the addition of adenosine triphosphate to the system, and determinations of negmine were made by the same method as that used for creatine[1].

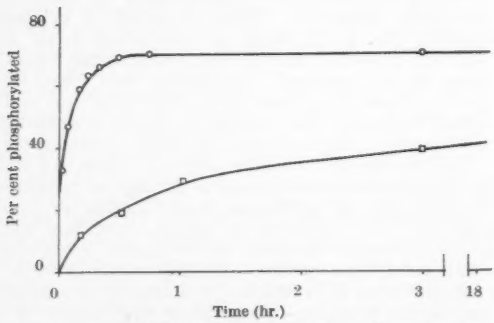

Fig. 1. Rate of phosphorylation of creatine (○—○) and negmine (□—□) by the creatine phosphokinase – adenosine triphosphate system

It will be noted that negmine was phosphorylated, but at a much slower rate than was creatine. On the other hand, the amounts of each which were phosphorylated in the maximum time-interval investigated (18 hr.) were not greatly dissimilar.

The product of the reaction, phosphonegmine, was not isolated; but its properties (Table 1) are similar to those of phosphocreatine in the ease with which it may be hydrolysed under mild conditions (9 min., 0·1 *N* hydrochloric acid, 65°). It will also be noted that, as with creatine, there is an almost quantitative recovery of negmine following hydrolysis.

The fact that negmine may be phosphorylated by the creatine phosphokinase – adenosine triphosphate system is of importance, for, since the administration of glycocyamine is not followed by the excretion of glycocyamidine, and since glycocyamine is not phosphorylated by this system[3], it may be inferred that creatinine does arise from phosphocreatine[4,5]. This does not, however, provide proof of the hypothesis[5] that creatinine arises as a result of the non-enzymic breakdown of phosphocreatine. The results also confirm the belief[2] that the urinary excretion of negmidine followed the *in vivo* formation of phosphonegmine.

Table 1. Recovery of Creatine and Negmine by Hydrolysis for 9 min. at 65° in 0·1 *N* Hydrochloric Acid after Reaction with Creatine | Phosphokinase – Adenosine Triphosphate for 18 hr.

	Initial	Final (18 hr.)	Final (after hydrolysis)
Creatine (μmoles)	20·0	7·2	19·6
Negmine (μmoles)	20·0	8·0	19·6

The complete results of this investigation will be reported in greater detail elsewhere.

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Mode of Action of Tetanus Toxin

Though the general effects produced by tetanus toxin on the nervous system have been reported by many investigators, there is still no precise evidence as to its mode of action[1]. Sherrington[2] pointed out that tetanus toxin closely resembles strychnine in many of its effects, and postulated that both substances convert synaptic inhibition into excitation. Recently[3], it has also been found that tetanus toxin resembles strychnine in that the monosynaptic tendon jerk is but little affected by moderate dosage. Since it has now been shown that strychnine acts specifically by diminishing all types of synaptic inhibitory action[4,5], it was of interest to investigate the action of tetanus toxin on synaptic inhibition.

The tetanus toxin was administered by injection within the sheath of the sciatic nerve in order that its effect on the spinal cord would initially be localized, and hence control responses would be provided by the other side. The procedure for investigating direct inhibition resembled that already described[4], single maximum volleys in the large stretch afferents from quadriceps muscle being employed to inhibit the monosynaptic reflex discharges which were evoked from biceps-semitendinosus motoneurones at varying testing intervals thereafter. In Fig. 1 the inhibitory curves so constructed at 21–43 hr. after the injection of the toxin give a typical illustration of our experimental findings. The earliest test, at 21 hr., revealed that the inhibition amounted to 65 per cent, in

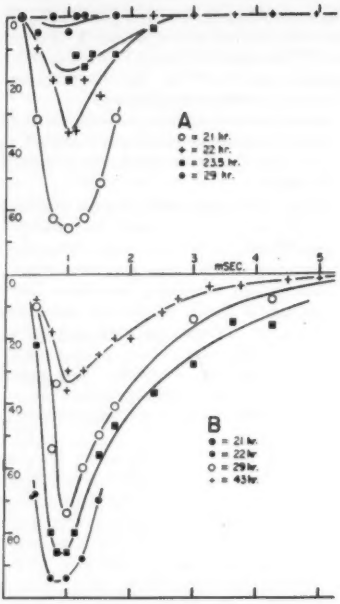

Fig. 1. Curves showing time courses of direct inhibition of monosynaptic reflex from biceps-semitendinosus motoneurones of the spinal cat under light 'Nembutal' anæsthesia. The symbols denote the inhibitory effects observed at the times indicated after the injection of 7 mgm. of tetanus toxin (Wellcome *XB* 1322. *T*.166) in 0·05 ml. normal saline under the sheath of the left sciatic nerve at the mid-thigh level. Figs. 1 *A* and *B* were obtained respectively on the left and right sides. The percentages of inhibition of the monosynaptic reflex spike (ordinates) are plotted against the various intervals (in m.sec.) by which the testing excitatory volley follows the initial inhibitory volley (abscissæ). Each plotted percentage is the mean of ten to twenty observations

contrast to 95 per cent on the contralateral side. Subsequent tests at 22 and 23½ hr. showed the rapid diminution of the inhibition to about 35 and 15 per cent respectively, while it was still little affected on the contralateral side. By 29 hr. the respective inhibitions were less than 5 per cent and about 75 per cent. The slow diminution of the contralateral inhibition was kept under observation until it was only about 35 per cent at 43 hr., while on the ipselateral side all trace of inhibition had disappeared many hours earlier. During all this period the testing monosynaptic reflex spike showed little change in size and remained virtually the same on the two sides. Thus the experimental series of Fig. 1 shows typically that tetanus toxin resembles strychnine in that it selectively suppresses inhibitory action, while synaptic excitatory action is unaffected.

All other types of inhibitory action in the spinal cord have similarly been suppressed by tetanus toxin and strychnine. It has further been found that tetanus toxin has no effect on the synaptic relays that occur on the direct inhibitory pathway[6] and on the antidromic inhibitory pathway[5]. Finally, intracellular recording from motoneurones has indicated that the inhibitory hyperpolarization is suppressed by tetanus toxin, exactly as occurs with strychnine. Thus there are two likely explanations of the action of tetanus toxin: that, like botulinum toxin, it may prevent the release of the transmitter substance[7]; or that, like strychnine, it may become attached to the subsynaptic inhibitory areas on the motoneuronal membrane, preventing the action thereon of the inhibitory transmitter.

Besides acting as a control, the contralateral observations (Fig. 1*B*) illustrate the slow spread of the action of tetanus toxin in the spinal cord that has been reported by previous investigators[1–3]. Inhibition in the segment rostral to that illustrated in Fig. 1 showed much the same slow development of inhibitory depression as in Fig. 1*B*, the inhibitory effect being halved at about 30 hr. Concurrently with the gradual suppression of inhibitory action, there was a large development of polysynaptic reflexes, similar to that produced by strychnine. This effect could be satisfactorily explained by the depression of inhibitory synaptic action on the interneurones of these polysynaptic pathways, that is, tetanus toxin appears to depress inhibitory action on interneurones as well as on motoneurones.

It may be concluded that, in confirmation of Sherrington[2], the action of tetanus toxin on the spinal cord closely resembles that of strychnine; but both these substances act, not by converting synaptic inhibition into excitation, but by suppressing all types of synaptic inhibition. It is probable that general tetanus is also similarly explained by the general suppression of synaptic inhibitory action as the tetanus toxin spreads throughout the whole nervous system.

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Effect of Background Activity on the Action of Acetylcholine on the Electrical Activity of the Brain

Recent experiments have led to the suggestion[1] that the physiological action of acetylcholine on the activity of the brain might be conditioned by the state of excitation of the brain itself.

As a preliminary test of this possibility, two series of experiments have been carried out on rats, rabbits and cats. In the first series, electroencephalograms were recorded from needle electrodes in the intact skull, and acetylcholine was rapidly injected into the internal carotid artery. In the second series, a 'Perspex' irrigation chamber was fixed tightly into a trephine hole in the skull, and Ringer–Locke solution—to which acetylcholine could be intermittently added—was passed slowly through the chamber. The electroencephalogram was recorded from a fine electrode, insulated to the tip, in contact with the exposed cortex. When administered by either route, to an animal anæsthetized with 'Dial', acetylcholine caused, as was expected, excitation with small doses and depression with larger doses, the threshold dose for excitation being, for intracarotid administration in the rabbit, of the order of 1–2 μgm. In irrigation experiments the doses required were higher (25 μgm.

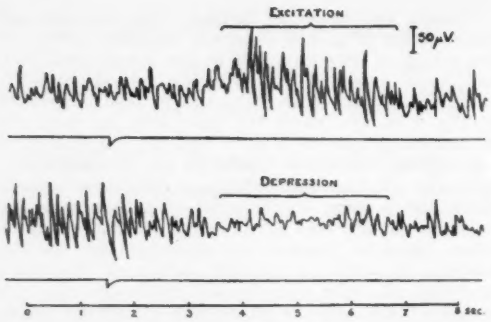

Fig. 1. Electroencephalogram record from exposed irrigated cortex of rabbit. Upper tracing, animal under 'Dial' alone; lower tracing, animal under 'Dial' + leptazol. At signal, acetylcholine (25 μgm.) added to irrigation fluid: excitatory action of acetylcholine on quiescent cortex; depressant effect on activated cortex

for excitation), but the effects were qualitatively similar.

When the cortex of the anæsthetized animal was activated by the intraperitoneal injection of 'Leptazol' (80 mgm./kgm.), doses of acetylcholine which were previously excitatory became inhibitory, a typical result being illustrated in Fig. 1. Doses previously ineffective remained so, while the inhibitory effect of larger doses became less well marked.

The addition of adrenaline (10^{-4} *M*) to the Ringer–Locke solution irrigating the exposed cortex caused a significant reduction in the threshold dose of acetylcholine required for excitation or inhibition.

None of the effects mentioned could be attributed to the vascular actions of acetylcholine.

This work will be described more fully and discussed elsewhere.

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Long-term Suppression of a Permeability Response of the Rat's Hind-paw by Cortisone, by Hypophysectomy and by Protein-deficient Diet

Some three years ago, we reported that crude testicular extracts containing hyaluronidase greatly increase permeability in the rat's hind-paw[1]. 0·3–0·8 mgm. of crude extract is dissolved in 0·11 ml. saline and injected at the plantar side; each animal serves as its own control. The acute œdema—surpassing that caused by the usual doses of dextran—contains 4·0–5·5 gm. protein per 100 ml. The presence of histamine was demonstrated by the guinea pig ileum test as well as by partition paper chromatography, the concentration being 2·5–4·5 μgm. per ml. The significance of this histamine, as well as the influence of local reactivity of the tissues of the hind-paw, and the influence of age differences will be discussed separately. We find that young rats regularly show 'full' œdemas in our colony, although the response tends to diminish gradually with advancing age.

In earlier papers[2–4] we dealt with the possibilities of influencing permeability in acute experiments. Pharmacological doses of salicylate, of natural adrenaline, etc., inhibited remarkably the production of œdema. The significance of the presence of the adrenal glands, as well as the importance of circulatory factors, were emphasized.

In the present communication we are dealing with the long-term changes in this permeability response. Each of three groups of experiments relates to 25 animals, or more.

(*a*) Cortisone (subcutaneous) was a potent material inhibiting œdema[5]. The dose necessary to produce full inhibition, however, was remarkably high. About 10 mgm. per 100 gm. for the adult rat and 10–20 mgm. for rats weighing less than 100 gm. was the effective dose if single injections were given. The protection against œdema mostly appeared on the second day, or even later; but it was demonstrable for several days or even a week. The massive dose of 50 mgm. cortisone acetate subcutaneously per 100 gm. rat inhibited œdema induced by testicular extract for a month.

(*b*) A second type of long-term suppression of œdema production of the hind-paw was that of hypophysectomized animals. The time of appearance of this change in permeability response varied; but animals with perfectly evacuated sella mostly failed to react with a sufficient œdema from one to four weeks after the operative procedure until death. It is to be noted that cases were observed with returning response; but hypophysial residue was detected in these cases with the lack of atrophy of endocrine organs. A remarkable lack of permeability response could be thus produced without any hypophysio-adrenocortical activation and/or in the absence of effective amounts of cortisone.

(*c*) As the greatly diminished response of the chronically hypophysectomized rats could certainly not be explained by cortisone action, we searched for a possible common explanation. Alteration of the protein metabolism seemed to be the possible common pathway. The third group of animals, thereafter, consisted of young normals held on a protein-deficient diet containing foodstuffs with the protein content less than 2·0 per cent. No other constituent was restricted. An example of this type of experiment (16/17, five rats) is as follows: body-weight 50–75 gm.; average body-weight decrease after 15 days, 10 per cent; average caloric intake, 19·9 cal. a day each rat; per cent of protein calories, 9·2. About 15–25 days later the grade of the acute œdema was very slight, if any. All animals were 'hyporeactors' from this point of time, and the response did not return until normal, or protein-rich, diet was introduced. This latter, however, evoked a quick return of the original reaction, that is, within 24–72 hr. More time is needed, however, to restore normal response, if the dietary protein deficiency is maintained for several days. Like the animals of groups (*a*) and (*b*), the growth of these young rats ceases, and a moderate diminution in the body-weight is the rule. The plasma protein concentration did not change significantly.

The present results are not opposed to the possibility that dehydration of the connective tissue (that is, a shift of water from the cells into the extracellular compartment and simultaneous phenomena, including eventually alterations in the metabolism of the cement-substances) may be important in the effects produced by the protein-deficient diet. Based on these observations, the explanation of the influence of pharmacological doses of cortisone, at least that

exerted on permeability mechanisms, seems to be in the field of the alterations of protein metabolism and its consequences. Similar changes are apparent after hypophysectomy. Our results suggest that long-term suppression of permeability is attainable, if the metabolism of water-binding molecules is altered, whereas only transitory suppression results if dehydration is produced without long-term influencing of water-binding macromolecules.

Details of these experiments will be published in *Acta Medica Hungarica*.

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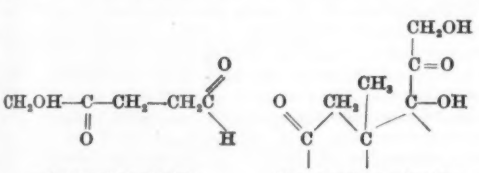
A Colorimetric Reaction for the Estimation of Cortisone, Hydrocortisone, Aldosterone and Related Steroids

IT was shown by Stacey *et al.*[1] that one of the substances responsible for the development of colour in the Dische reaction[2] for deoxynucleic acid is ω-OH-lævulinic aldehyde. Slight changes in this molecule resulted in the development of different colours. An examination of the formulæ of cortisone and hydrocortisone shows the presence of reactive groups similar to those of ω-OH-lævulinic aldehyde:



ω-OH-lævulinic aldehyde

Part of cortisone structure

Both compounds have terminal ketol groups and a carbonyl group five or six carbons distant from the primary alcohol group.

Accordingly, the diphenylamine reagent, suitably modified to improve the intensity of the reaction, was applied to various steroids. (*A*) Reagent mixture: 54 ml. of glacial acetic acid; 6 ml. of concentrated sulphuric acid; 10 ml. of distilled water; 600 mgm. diphenylamine. (*B*) Blank mixture contains the same reagents except that diphenylamine was omitted.

Depending upon the nature of the steroid, 10–50 γ of material may be determined in a micro-procedure using 1 ml. of reagent, and 50–400 γ using 3·0 ml. of reagent.

Two equal aliquots of the steroid solution are evaporated to dryness in test-tubes. To one test-tube is added reagent mixture and to the other an equal volume of blank mixture. The test-tubes are then heated in a boiling water-bath for 1 hr. to obtain maximum development of colour. The solutions are cooled to room temperature in running tap water and are observed in a Beckman spectrophotometer, either model *B* or *D.U.* The colours are stable for several hours and obey Beer's law in the ranges tested, namely, 10–400 γ. The instrument is set at zero optical density with the blank mixture, and the optical density of blank mixture plus steroid is observed. The instrument is now set at zero optical density with the reagent mixture, and the optical density of reagent mixture plus steroid is observed. The difference between the optical density of reagent mixture plus steroid and the optical density of blank mixture plus steroid is a measure of the amount of steroid present.

Table 1

Steroid (200 μgm. in 3·0 ml.)	Colour
Corticosterone (compound *B*)	yellowish-green
Deoxycorticosterone	faint yellow
17-OH-Corticosterone (hydrocortisone)	green
Hydrocortisone acetate	green
17,21-Dihydroxy-(3,20-dione)-$\Delta^{4,5}$-pregnadiene (anhydro *F*)	green
3α,11β,17,21-Tetrahydroxypregnane-20-one (tetrahydrohydrocortisone)	green
17-OH-11-Deoxycorticosterone (substance *S*)	green
11-Dehydrocorticosterone (compound *A*)	violet
21-Hydroxypregnane-3,11,20-trione (dihydro *A*)	faint pink
3α,21-Dihydroxypregnane-11,20-dione (tetrahydro *A*)	colourless
17-OH-11-Dehydrocorticosterone (cortisone)	violet
Cortisone-21-aldehyde	violet
Cortisone acetate	violet
3α-17,21-Trihydroxypregnane-11,20-dione (tetrahydrocortisone)	violet
Δ^5-Dehydrocortisone acetate	violet
Progesterone	faint yellow
11-Ketoprogesterone	faint yellow
11-β-OH-Progesterone	faint yellow
6β-OH-Testosterone	colourless
Δ^4-Androstene-3,17-dione	faint yellow
Δ^4-Pregnene-11β,21-diol-3,20-dione-18-al (aldosterone)	blue

The colours obtained with different steroids are shown in Table 1. Although some steroids gave no visible colour with the amounts used, all absorbed to some extent. The curves in Fig. 1 show the absorption spectra of the steroids after the blank values are subtracted.

Those steroids that contained keto-groups at the 11 and 20 positions and hydroxyl groups at the 17 and 21 positions gave similar characteristic absorption curves with a maximum at 530 mμ. These compounds gave distinct violet colours. The elimination of the hydroxyl in position 17 as in compound *A* merely decreased the intensity of colour without changing the shape of the curve. Increased saturation of the compound as in the 'dihydro' or 'tetrahydro' forms decreased the intensity of colour.

Those steroids that contained hydroxyl groups at positions 11, 17 and 21 and a ketone at position 20 gave a green colour with a maximum absorption in the range of 630–650 mμ. Again, saturation, as in 'tetrahydrohydrocortisone' or the absence of the 17-OH group, decreased the intensity of colour. However, substance *S*, which has a hydroxyl in position 17 instead of in position 11, gave almost the same absorption as hydrocortisone.

Fig. 1 also shows the absorption spectrum of approximately 50 γ of aldosterone (kindly supplied by L. H. Sarett, of Merck and Co., Inc.). The maximum at 640 mμ indicates the presence of a hydroxyl group at C_{11}. In addition, there was a peak at 530 mμ and a negative value at about 450 mμ. This compound gave a distinct blue colour which was not obtained with any of the other steroids tested.

Steroids of the progesterone and testosterone type gave practically no absorption at 530 mμ or 630–650 mμ, as compared with cortisone or hydrocortisone.

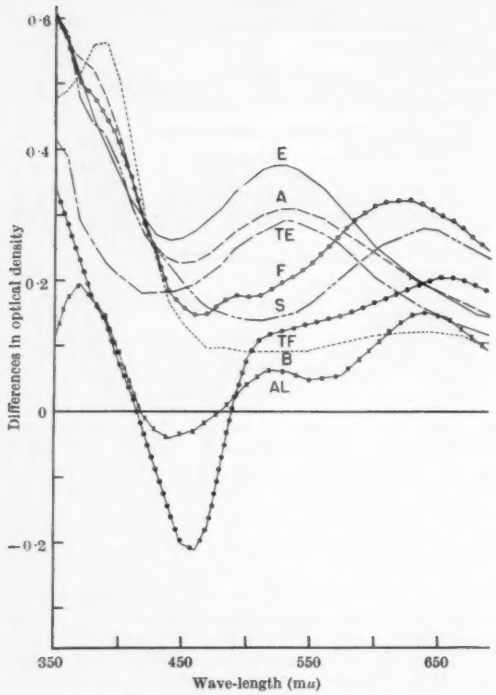


Fig. 1. (*E*), Cortisone (17-OH-11-dehydrocorticosterone); (*A*), Compound *A* (11-dehydrocorticosterone); (*TE*), Tetrahydrocortisone (3α-17,21-trihydroxypregnane-11,20-dione); (*F*), Hydrocortisone (17-OH-corticosterone); (*S*), Substance *S* (17-OH-11-deoxycorticosterone); (*TF*), Tetrahydrohydrocortisone (3α,11β,17,21-tetrahydroxypregnane-20-one); (*B*), Compound *B* (corticosterone); (*AL*), Aldosterone (Δ⁴-pregnene-11β,21-diol-3,20-dione-18-al)

The substitutions essential for the violet colour and the characteristic absorption spectrum of cortisone and similar steroids are (1) a hydroxyl at C_{21}, (2) keto-groups at C_{11} and C_{20}. Those necessary for the development of the green colour and characteristic absorption spectrum of hydrocortisone and related steroids are (1) hydroxyl groups at C_{21} and C_{11} or C_{17} and (2) a keto-group at C_{20}.

Since different absorption maxima are obtained with cortisone and hydrocortisone, it is possible to calculate the amounts of both substances by using the maximum absorption value of cortisone and the isosbestic point of the two steroids. This can also be done with mixtures of any two steroids if one reacts similarly to cortisone (for example, compound *A*) and the other similarly to hydrocortisone (for example, compound *B*).

The negative value observed with 'tetrahydrohydrocortisone' (Fig. 1) appears to be characteristic of this substance and can be used for identifying it in mixtures of steroids. It is the result of a reaction between this steroid and the blank mixture. Similar reactions occur between the other steroids and the blank mixture, particularly substance *S*, compound *B* and hydrocortisone; but none of these causes any significant interference in the range 500–650 mμ.

Of the steroids listed in Table 1, it is doubtful if many will appear simultaneously in biological fluids such as blood or urine. If the mixture is not too complex, the eleven oxygenated steroids may be determined in the presence of the 11-hydroxylated steroids. This method, with an appropriate extraction, is being applied to biological material and will be reported in the near future.

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Differences between Rates of Metabolism of Benzene Hexachloride in Resistant and Susceptible Houseflies

In a previous communication[1], the metabolism of γ-BHC was described after injection into three strains of flies: a susceptible strain (*S*), a strain resistant to γ-BHC (R_1), and a strain resistant to γ-BHC and DDT (R_2).

The rate of metabolism in the susceptible strain was not comparable with that of the resistant strains, since the former died rapidly, whereas the latter remained unaffected. Thus it was impossible to tell whether the difference in metabolism could be a cause of the difference in susceptibility.

Hitherto, the method of estimation did not permit the study of the metabolism at doses low enough to leave also strain *S* unaffected. However, the problem becomes accessible for experimentation if we assume that all isomers of BHC are metabolized by the same mechanism. Then the breakdown in the strains can be studied in comparable circumstances, as it is possible to estimate the α- and δ-isomer at concentrations that are not at all toxic to the flies.

The flies were injected into the thorax with BHC in an emulsion of peanut oil, and kept at 25° C. for varying periods of time, after which the amount of BHC was estimated. The results are presented in Fig. 1 and Table 1. It is shown that there is a difference in breakdown of the α- and δ-isomer between the susceptible and resistant strains. This difference is somewhat larger in the case of the α-isomer. The breakdown of the δ-isomer is markedly slower than that of the α-isomer. As for technical reasons the experiments were not extended beyond 24 hr., it was impossible to obtain the complete breakdown curve for this isomer.

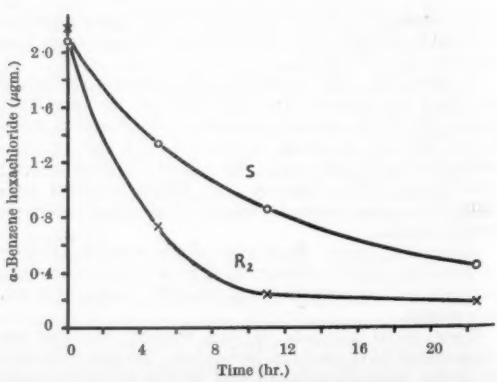

Fig. 1. Amount of α-BHC per fly plotted against time after injection. *S*, susceptible strain; R_2, γ-BHC and DDT-resistant strain. Fifteen flies used for each estimation

Table 1. BREAKDOWN OF α- AND δ-BHC
Thirty flies used for each estimation; horizontal lines represent injections on the same day

Isomer	Amount injected per fly (μgm.)	Time between injection and estimation (hr.)	Breakdown (per cent) S	R_2	R_1
α	0·83	4	36	60	80
	0·93	4	36	57	57
	0·67	4	45	55	65
	2·34	5	34	—	57
	2·34	5	43	—	71
	2·34	5	40	57	—
	2·34	5	23	50	69
δ	2·34	18½	28	43	—
	2·34	18½	29	32	—
	2·34	18½	25	32	—
	2·34	18½	27	46	47
	2·34	18½	27	39	37

If our hypothesis is correct, the difference in rate of breakdown of γ-BHC between the susceptible and resistant strains has two causes: (1) a difference in breakdown capacity—a possible cause of difference in susceptibility; (2) a decreasing rate of breakdown in the susceptible strain as a result of the toxic action of γ-BHC—an effect of the susceptibility.

If we assume that the metabolism results in a detoxication, it is very probable that the difference in metabolism is a cause of the difference in susceptibility, although it is as yet impossible to estimate its importance. For example, it is not known how the rate of breakdown affects the concentration at the site of action. Work with more strains will perhaps be helpful in judging the significance of rate of breakdown for resistance, as it may reveal whether there exists a correlation between capacity of breakdown and level of resistance.

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Lysis of Human Pathogenic Bacteria by Myxobacteria

ALTHOUGH great interest has been taken in recent years in isolating antibiotics from various groups of micro-organisms, Myxobacteria have received so far very little attention. Several workers have reported the lysis of bacteria (Eubacteria) by species of Myxobacteria; but no satisfactory evidence has been produced that living cells are attacked. It has been shown by Singh[1], who used a large number of strains of bacteria, that certain species of Myxococcaceae undoubtedly cause lysis of both Gram-positive and Gram-negative living bacteria upon solid media. Oxford and Singh[2] and Oxford[3] have shown that a strain of *Myxococcus virescens* growing on cell-free medium is able to produce two substances, an exocellular lytic (proteolytic) enzyme and an antibiotic. Noren[4] has confirmed and extended this work to other species of Myxobacteria and has devised more suitable media for the production of the proteolytic enzyme and the antibiotic. The present work deals with the lysis of human pathogenic bacteria by two species of *Myxococcus*.

A strain of *Myxococcus virescens* and *M. fulvus* was tested on strains of bacteria by Singh's method[1]. In all the experiments twenty-four hour old cultures of bacteria, grown at 37° C. on nutrient agar slopes, were used. Two streaks (about 1 in. long) well separated from each other, of a bacterium to be tested, were made on a non-nutrient agar plate (1·5 per cent agar, 0·5 per cent sodium chloride; *p*H 7·0). One of the streaks was inoculated at one end with fruiting bodies of a Myxobacteria growing on living *Aerobacter* sp. and the other was left as control. The culture was incubated at 37° C. and examined at 2–6 days.

Table 1 shows the lysis of bacterial strains by two species of Myxobacteria. Of the bacteria tested by the above method, some were readily or slowly but completely lysed, others showed partial lysis and *Mycobacterium phlei* was not lysed. The dysentery, cholera and typhoid groups of organisms were attacked to varying degrees. *Shigella sonnei*, *S. paradysenteriae* Flexner, *Vibrio cholerae* Ogawa 49514, *Salmonella typhosa* and *S. typhosa* Vi–*I* were completely lysed by *M. virescens* and only partially by *M. fulvus*. *V. cholerae* Rough 49515 was, however, lysed completely by the latter and only partially by the former.

Table 1. LYSIS OF BACTERIAL STRAINS BY MYXOBACTERIA

Bacterial strains tested	*Myxococcus virescens*	*Myxococcus fulvus*
Staphylococcus aureus	*Pl*	*Pl*
Bacillus subtilis	*Pl*	*Pl*
Mycobacterium phlei	*Nl*	*Nl*
Shigella dysenteriae Shiga	*Pl*	*Pl*
S. sonnei	*Cl*	*Pl*
S. paradysenteriae Flexner	*Cl*	*Pl*
Vibrio cholerae Ogawa 49514	*Cl*	*Pl*
Vibrio cholerae Rough 49515	*Pl*	*Cl*
*Proteus X*19	*Cl*	*Cl*
Salmonella paratyphosa	*Cl*	*Cl*
Salmonella typhosa	*Cl*	*Pl*
Salmonella typhosa O-901	*Pl*	*Pl*
Salmonella typhosa H-901	*Cl*	*Cl*
Salmonella typhosa Vi–*I*	*Cl*	*Pl*

Cl = completely lysed either readily or slowly; *Pl* = partial lysis; *Nl* = not lysed.

In order to find out whether the rate or the extent of lysis of the susceptible pathogenic bacteria (Table 1) by Myxobacteria could be improved, *M. virescens* and *M. fulvus* were grown and subcultured a few times on the same organisms. No marked difference in the lysis of the organisms was observed as compared with the results presented in Table 1.

M. virescens and *M. fulvus* were grown on non-nutrient agar plates with *Aerobacter* sp. and *Staphylococcus aureus* at 26°, 30° and 37° C. The growth of Myxobacteria was better at 30° and 37° C. than at 26° C., the effect being more marked in the case of *M. fulvus*. The temperature-range of 30°–37° C. was also more favourable for the production of fruiting bodies of Myxobacteria. This is in accord with the findings of Noren.

Our thanks are due to Dr. B. N. Singh, assistant director, Microbiology Division, of this Institute, for his interest in this work.

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Relationship of Ovarian Hormones to the Pyogenic Effect of *Corynebacterium pyogenes*

Rowson, Lamming and Fry[1] and Lamming and Rowson[2] have reported that purulent infections rapidly become established in the uterus of the cow following introduction into the uterus of infected bull semen or cultures of *C. pyogenes* during the luteal phase of the œstrous cycle, but infections introduced into the uterus of cows in œstrus fail to become established. Using ovariectomized cows, the resistance and susceptibility of the bovine uterus to infection was shown to be due to the action of œstrogens and progesterone respectively. The possibilities suggested to account for the variation in resistance to infection include: (*a*) an increase in leucocyte activity during œstrus, (*b*) an increase in antibody activity during œstrus, (*c*) the production in the uterus during the luteal phase of an environment suitable for rapid bacterial development. The present work is concerned with the effects of the uterine environment.

Uteri were removed at slaughter from cows and rabbits which were in the luteal phase and from cows during the follicular phase and in anœstrus, and from rabbits injected one day previously with 10 mgm. stilbœstrol and in anœstrus. Using aseptic precautions, blood samples were also collected from the rabbits by heart puncture and from the cows by bleeding from the jugular vein. Blood samples were also collected from cows during the luteal phase, in œstrus, and from pregnant cows.

The primary aim of the work was to establish whether or not the uterus of the œstrous animal contained substances which were antibacterial in action. Using aseptic precautions, the uterine mucosa of cows and rabbits was exposed and a small circle (0·5–2·0 cm. diameter) of sterile filter paper was pressed against the uterine mucosa to make a swab. Two swabs from each animal were placed on horse blood agar inoculated with *C. pyogenes*. In some cases additional swabs from cow and rabbit uteri were placed on rabbit blood agar or cow blood agar containing *C. pyogenes*. Small strips of uterine mucosa from both species were also placed in horse-, cow- or rabbit-blood agar plates with and without *C. pyogenes*. Rabbit blood was obtained by heart puncture from animals injected intramuscularly one day previously with 10 mgm. stilbœstrol; and blood samples were obtained both from pregnant cows and those in the œstrous and luteal phases. Two or three drops of plasma, or whole blood, on separate sterile filter disks were placed on horse blood agar plates with and without *C. pyogenes*.

Preliminary results using strips of uterine mucosa and swabs of uterine fluid showed an increased zone of hæmolysis, 3–5 mm. wide, on horse blood agar plates containing *C. pyogenes* when the tissues or swabs were taken from either a cow in the follicular phase, an anœstrous cow, or a rabbit treated with stilbœstrol. There was no zone of hæmolysis on horse blood agar plates containing *C. pyogenes* when the uterine tissue or swab originated from either an anœstrous rabbit, cows in the luteal phase or in rabbits 3–6 days post-ovulation. There were no zones of hæmolysis on horse, cow or rabbit blood agar plates without *C. pyogenes* whatever the origin of the tissue or swabs.

That a combination of *C. pyogenes*, horse blood agar and material taken from an animal during a particular phase of reproductive activity will cause increased hæmolysis is unusual and interesting. The zones of increased lysis occurred when tissues or blood plasma were taken from animals which, on the basis of the earlier work, would be expected to be resistant to experimental uterine infections. It seems probable that these zones of increased lysis are not associated with more active growth of the test organism. That the zones of increased lysis can be demonstrated using blood plasma as well as uterine swabs and uterine tissue suggests that a general physiological effect may be present. Work is continuing to decide whether the effect is due to specific antagonistic or stimulatory effects of the sex hormones, or their analogues.

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Competition among Wild Rats

Observations in the field and in large enclosures have shown that feral rats (*Rattus norvegicus* Berkenhout), unlike albinos of this species, display, in a highly developed form, both territorial and other types of competitive behaviour[1–3]. Interspecific competition, between *R. norvegicus* and *R. rattus* L., has also been directly observed[2]. These studies have, however, thrown little light on the exact circumstances which evoke competition, or on the precise nature of the behaviour involved.

Colonies of both species of rats have been maintained in cages of about 1 cu.m., with attached nest boxes. Cinematograph films have been taken of some colonies in a cage with a glass front. The rats were marked with a depilatory. In these conditions, groups of adult males of both species, trapped in Glasgow or bred from rats so trapped, have lived for up to twenty-two weeks without mortality, and usually without injury. Generally, several individuals slept together in a nest box, without distinction of species. Thus competitive behaviour is not necessarily evoked by the presence of another male, or by a member of a closely related species. In these experiments all the males were introduced, at the same time, into an unfamiliar cage. However, as described also elsewhere[2], *R. norvegicus* males newly introduced into an established colony were often persecuted by members of their own species: some died within a few days. This type of competitive behaviour is evidently the result of the establishment of a territory. Females of both species will also live together without conflict. Non-parturient females differ from males, however, in not showing territorial behaviour.

R. norvegicus males, put in cages together with females of the same species, fight vigorously. In the first of such experiments only one (the heaviest) out of six males survived after eleven weeks. Control males, litter mates of the experimental animals, kept singly in small cages each with one female, showed no mortality; these pairs have produced many viable litters. Females do not fight as males do, and they nearly always survive the experiments without injury. They readily become pregnant during the

experiments; but there is a high mortality among the nestlings. Thus competition in this species is markedly different in the two sexes, and it can be evoked among males by the presence of females.

Fighting does not involve serious wounding to either rat involved; though vigorous, it is formal rather than, in itself, lethal. Injuries may include superficial damage to tail or ears, or occasionally to limbs; sometimes the skin is torn in the neck region. Deaths appear to be due to exhaustion rather than to wounding, and sometimes occur without detectable external damage. In the male–female colonies, the weights of some males rose during the experiments; but the weights of most fell. All the control males in small cages increased in weight. The experimental males which grew most tended to be those which were initially heavier than the rest; some of these successful males grew more than any of the controls.

Adrenal glands of males used in these experiments were removed, weighed and examined histologically. The adrenal cortex of subordinate rats involved in severe fighting over short periods, for example, two days, showed marked depletion of sudanophilic material, such as is found also in other forms of 'stress'[4]. On the other hand, subordinate males examined after some weeks of exposure to moderate competition showed little or no depletion; in these, however, there was evidence of hypertrophy of the adrenal cortex, since the relative weights of their adrenals were higher than those of the controls. Dominant males, which had fought just as much, or more than, the depleted subordinate males, showed no depletion. This suggests that the exhaustion of subordinate males is not merely a consequence of violent exercise, but also involves more complex nervous and endocrine changes.

The method described here allows detailed observation and filming of the social behaviour of marked rats, and makes it possible to relate the behaviour seen to physiological changes revealed at autopsy. The results indicate that competition among wild rats is evoked by a number of quite specific situations, which can be analysed by experiment in the laboratory. Full accounts of this work will be published elsewhere.

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Black Grub Infection in *Catla catla*

More than 150 fingerlings of the fish *Catla catla* (Ham. Buch.) collected in July 1953 from freshwater sources in Samalkot, East Godavari District, Madras, were heavily infested with black grub cysts embedded under the skin and distributed all over the body. In one specimen, more than three hundred cysts were encountered. Cysts were excised and ruptured under a coverslip to release the larva, with or without its own envelope, and its organization studied by clearing it with phenol.

The black colour is due to the dendritic pigmentation on the fibrous, elliptical host-cyst, inside which floats the colourless larva invested by a gelatinous parasite-cyst. The parasite proved to be a metacercaria of a strigeid trematode.

Its structural details (Fig. 1) are briefly as follows: body typically bi-lobed, with almost equal halves, the fore-body filled with glands and less transparent than the hind-body; oral sucker broader than long, pharynx elongated, œsophagus narrow and slender, and intestinal cæca extending far into the hind-body; accessory suckers laterally situated, prominent and larger than the oral; acetabulum smaller than the oral sucker, placed in the region of the bifurcation of the œsophagus; hold-fast organ immediately behind it, nearly as large as the accessory suckers, circular or oval, with a longitudinal cavity; genital rudiments confined to the hind-body and recognizable as an oval, slightly lobed ovary to the outside of the cæcum, three lobes of testes, of which two are elongated and overlie the cæca and the third is oval and apposed to one of them; two branched excretory ducts on the inside aspect of the cæca unite posteriorly to open by a common terminal pore.

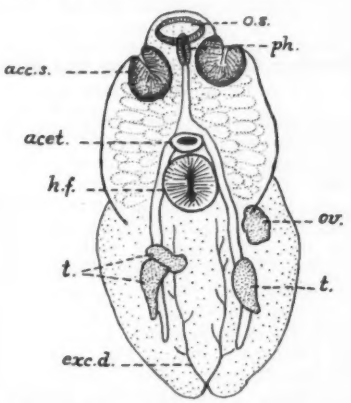

Fig. 1. Strigeid metacercaria from *Catla catla*. acc.s., accessory sucker; acet., acetabulum; exc.d., excretory duct; h.f., hold-fast organ; ov., ovary; o.s., oral sucker; ph., pharynx; t., testis

Among the several larval genera to which strigeid metacercariæ are attributed, *Diplostomulum* is one which possesses distinct accessory suckers; but it lacks a cyst-wall and inhabits mostly the eyes of fishes, though it may occur in other situations less often[1–3]. Black grub is caused by the genus *Neascus*[3,4], around which a host-cyst is developed. The metacercaria now described conforms to the morphological pattern of a *Neascus* in every aspect except for the possession of accessory suckers, and recalls the characters of the adult genus *Diplostomum* to a high degree.

To determine the identity of the adult worm, experimental infection of two ducks was attempted. Each bird was fed with live *Catla catla* having a heavy burden of metacercariæ; but no evidence of successful infection was obtained. Possibly other piscivorous birds like the egret and the snipe may prove susceptible.

It has been customary to recognize larval genera among Strigeids, and two of them—*Diplostomulum* and *Neascus*—have been referred to here as relevant, and it has been shown that the black grub of *Catla* does not correspond with either on all counts. But the similarity in structure between this one and the adult genus *Diplostomum* is emphasized to indicate the probable identity of the form.

This investigation is in progress as an item in the study of fish parasites, and a detailed account may be awaited. We are grateful to Mr. M. Devidas Menon, assistant director of fisheries, Madras, for providing facilities, to Dr. G. Dubois, Neuchâtel, for valuable information, and to the Director of Industries and Commerce, and the Director of Animal Husbandry, Madras, for permission to publish these observations.

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Molecular Orientation in the Wings of a Termite

The orientation of complex molecules in certain tissues is well known[1]. I have recently observed that, although the main structure of the wing of a termite (*Macrotermes* sp.) is isotropic, the two principal anterior veins (costal and sub-costal), running approximately parallel to the leading edge and to each other, show very marked anisotropy with the extinction direction parallel to the vein axis. These brown veins appear to contain both chitin and sclerotin.

X-ray photographs taken about the vein axis using copper K_α radiation lead to the idealized fibre diffraction patterns shown in Fig. 1 (*a* and *b*). In both cases the rings are barely visible except very near the sickles. The equatorial spacing of the untreated vein, Fig. 1*a*, is 4·63 A., the meridional one is 3·48 A., with the sickles corresponding to not more than 7° disorientation. These spacings could correspond either to fully extended β-keratin-type chains running in the direction of the vein axis (± 7°) with randomly orientated cross-linkages, or to orientated chitin molecules. It seems likely that both these sources are contributing to the total diffraction pattern.

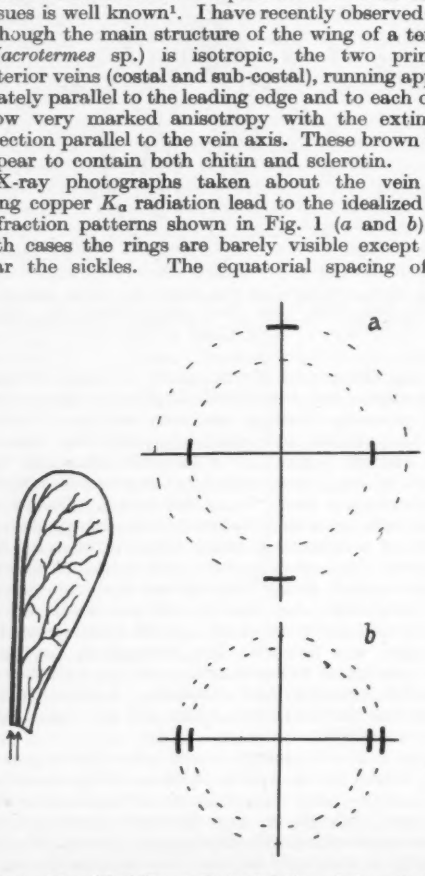

Fig. 1. (*a*) Original fibres; (*b*) treated fibre. Left: principal veins on wing, indicated by arrows: orientation corresponds to that of (*a*) and (*b*)

The veins may be cleaned and bleached by boiling them in concentrated potassium hydroxide for about twenty minutes. If the bleached vein is washed with ethanol and water and air-dried, the diffraction pattern of Fig. 1*b* can be obtained. This shows that the meridional spacing is no longer present; but that another equatorial spacing has appeared at 4·13 A., in addition to the former spacing at 4·63 A. Hence the principal chain must be largely disintegrated by boiling with potassium hydroxide.

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Photoelectric Cell Observations of Insects in Flight

Recent work in this Laboratory involved the exposure of a red-sensitive cæsium photoelectric cell to direct sunlight, the cell output being fed to a high-gain audio amplifier and a loud-speaker instead of the more usual d.c. amplifier-galvanometer chain. It was observed that occasional brief (< 0·25 sec.) random 'bursts' of sound occurred, of apparent frequency between 100 c./s. and 500 c./s. The number of 'bursts' in a given time varied considerably during the day, but appeared to rise to a peak in the late afternoon. No moving object which might immediately explain the phenomenon was visible to the naked eye, and the sound produced was quite different from the continuous 'rumble' produced when tenuous cloud drifted across the sun's disk.

The recording system was amended to use two photoelectric cells close together and feeding separate amplifiers. Observation of a number of 'bursts' showed that in many cases a burst recorded in one channel was followed after a discrete time-delay by a similar burst in the other channel. This suggested moving objects as the cause, and from the geometry of the system and the duration of a burst, established their speed as of the order of 5–10 m.p.h. and their range as relatively close.

Several of the bursts were recorded on magnetic tape and later played back, displayed on an oscilloscope, and their wave-forms photographed (p. 129). Fig. 1,*a* shows a typical burst of duration about 0·15–0·2 sec., and Fig. 1,*b* shows the same occurrence displayed on a faster sweep (150 m.sec.).

It is almost certain that these bursts of sound are caused by insects flying across the optical path between the sun's disk and the photoelectric cell, the generated frequency being due probably to the oscillation of the insect's wings, and the insects themselves being beyond the range of the unaided human eye or ear.

Several different types of captive insect, for example, bee, common housefly, have been exposed in a transparent container to the photoelectric cell and their wave-forms obtained. Fig. 1,*c* shows the wave-form produced by a bee fluttering its wings, photographed at approximately the same speed of sweep as was Fig. 1,*b*. It will be seen that there is a close

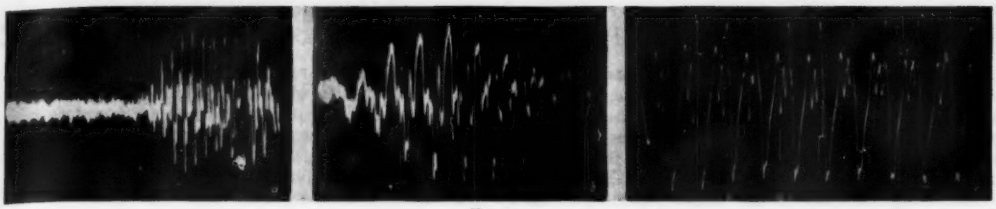

Fig. 1

similarity. The fundamental period here is about 80 c./s.; but the very high harmonic content makes the sound as recorded appear aurally much higher in pitch.

This phenomenon is reported here because it seems possible it might be turned to account by workers interested in the flight habits of insects, and particularly in variations in insect density during daylight hours.

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Optical Rotation and Polypeptide Chain Configuration in Proteins

Observations on the optical rotation of collagen and gelatin[1], together with consideration of polarimetric data reported in the literature for these and other proteins[2–6], have suggested the following simple hypotheses relating optical rotativity and polypeptide chain configuration:

(1) Randomized chain configurations, provided by conditions which cause 'denaturation', exhibit rotations believed to correspond to the sums of effectively independent contributions of the L-amino-acid residues present. Values of $[\alpha]_D$ in the neighbourhood of $-100°$ characterize such states. For example, when native globular proteins are denatured by urea or similar reagents, the rotation invariably changes from an initially low negative value to about the range $-80°$ to $-120°$ [2–4]. Hot gelatin sols from various sources also show similar rotations[1,5,6]. Deviations within or near this range probably depend on variations (*a*) in completeness of denaturation, (*b*) in the amino-acid composition of the proteins involved, or (*c*) in minor aspects of the predominantly aqueous environments used for the measurements.

(2) The rotation in the native state appears to be the result of effects of specific main-chain configuration superimposed on or otherwise changing the optical rotation from that of independent, asymmetric α-carbon atoms alone. The resultant total rotation of the native protein may be appreciably greater or less than is obtained after denaturation. Examples of the two possibilities are considered separately:

(*a*) It is suggested that the very high negative rotations of native collagen solutions may result in large part from a helical configuration characteristic of the polypeptide main chains. A citrate-soluble fraction of ichthycol (from the tunic of carp swim bladders) yielded[1] a specific rotation of $-350°$ under conditions which Gallop[7] has shown disperse the collagen as protofibrillar particles with mass per unit of (contour) length similar to that in normal condensed states (fibrils of connective tissues in general). Wide-angle X-ray diffraction studies have indicated that in these solid states there is helical structure along at least parts of the polypeptide chains[8]. Since the particulate cross-sections are not greatly altered during dispersion, it is reasonable to conclude that at least some of the helical configuration is retained in solution.

As suggested by Robinson[5], a recovery of the native backbone configuration by gelatin upon cooling accounts for the high rotation of gelatin in gels and in films formed by evaporation in the cold. The latter also yield the characteristic infra-red absorption and wide-angle X-ray diagram of collagen. Robinson described these phenomena in terms of a return of the specific 'collagen fold', which is here further described as helical. In comparable solution environments, however, the recovery seems to be incomplete, since gelatin does not fully regain the rotation of collagen[1].

(*b*) The specific rotations of native globular proteins are relatively low (-30 to $-60°$)[2,9]. Either (i) the main chain configuration is such as to oppose or to reduce the contributions of the α-carbon atoms weakly; or (ii) there are large cancelling effects resulting from enantiomorphic chain configurations. The latter alternative becomes more likely if modern concepts of the importance of helical polypeptide chain configurations prevail, and if the case of collagen is taken as indicating that polypeptide helices should exhibit strong rotation. A complete cancellation of backbone effects need not result from a mixture of equal numbers of left- and right-handed helices composed of L-amino-acids, since one cannot assume that the contribution to rotation from the backbone dissymmetry is strictly additive with that due to the asymmetric α-carbon atoms.

(3) Since the pyrrolidine residues have special significance for main-chain structure, they may also be influential in determining optical rotation. Helical configurations (including the α-helix) have no preferred sense of twist so long as imino-residues need not be incorporated frequently along the coil. In fact, the occasional presence of such residues provides a means of turning corners or of producing a reversal of sense of twist[10]. Thus, one might expect optically opposing chain configurations to occur in native globular proteins. On the other hand, the uniquely high proportion of imino-residues in collagen provides a possible stereochemical reason for helices of one sense of twist, hence for large optical rotation, in that protein.

An alternative explanation of the uniquely large rotation in collagen and cold gelatin, which seems less likely, is that the imino-residues may have unusually large rotations because of strains in the pyrrole ring, about the α-carbon, introduced when chains containing the pyrrolidines are impressed into the collagen configuration. In this case a specific

rotation of − 350° for the protein would correspond to an estimated rotation of about − 1,200° for these residues.

Finally, we may note that the comparisons made above have been based on rotations in the visible spectrum, in particular the sodium-*D* line, and that small differences in the rotatory dispersion bands, which are located in the ultra-violet for proteins, should not invalidate these generalizations. The possible significance of the exact position of these absorption bands as an additional criterion for backbone configuration has recently been pointed out by Linderstrøm-Lang and Schellman[11].

This work was supported in part by a grant-in-aid, for the study of connective tissue structure, under the supervision of Prof. Richard S. Bear, from the American Cancer Society upon recommendation of the Committee on Growth, National Research Council. I thank Prof. Bear for advice and encouragement, as well as Dr. Alfred Gierer for helpful discussions. This report is based on part of a Ph.D. thesis submitted to the Massachusetts Institute of Technology, June 1954.

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Gamma-Rays from Proton Bombardment of Sodium

The yield of the (p,γ) capture process in sodium-23 has been studied for proton energies ranging between 0·5 and 1·0 MeV.

Thin vacuum-evaporated sodium iodide and thick sodium sulphate targets were bombarded with protons from the van de Graaff generator. The magnetic field of the analysing magnet was measured by means of a proton resonance fluxmeter. As a detector for the γ-rays a sodium iodide (tantalum) crystal was used. Calibration was achieved by means of the 873·5 ± 0·8 keV. resonance in the $^{19}F(p,\alpha\gamma)^{16}O$ reaction[1].

Table 1

Curran (ref. *a*)	Tangen (ref. *b*)	Burling (ref. *c*)	Freeman (ref. *d*)	Turner (ref. *e*)	Our results	Rel. intensities
525	510 ± 5	515			512·0 ± 2	1
590		598	590	594·5 ± 1·5	592·3 ± 2	3
690		676*			677·0 ± 2	10
755		735	740		743·0 ± 2	4·5
875		867			873·7 ± 2	9

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* Misprinted as 576 in Burling's paper.

In Table 1 the resonances are listed and compared with the results of other authors[2]. The resonance near 874 keV. is in some papers supposed to be due to fluorine contamination. It has been shown recently[3], however, that there is also a sodium resonance close to that energy. The fluorine contamination in our targets was found to be less than one part in 500,000.

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Paramagnetic Resonance in Copper Phthalocyanine

Paramagnetic resonance measurements on copper phthalocyanine are of considerable interest for two reasons. First, the central structure of the phthalocyanine molecule is similar to that of hæmoglobin and chlorophyll[1], and hence any detailed information that can be derived on the electronic binding will be of great biophysical importance. Secondly, the copper atom is surrounded by four nitrogen atoms, and not water molecules, as in nearly all the copper salts previously studied by paramagnetic resonance. It was therefore expected that the observed g factors and hyperfine splittings might be somewhat different from the usual values[2], and this has been confirmed, the hyperfine splitting along the field axis being nearly twice as great as the maximum values previously reported.

Initial measurements on concentrated crystals have been briefly reported before[3]; but it has now proved possible to observe signals from diluted crystals, and thus resolve the hyperfine structure, and study its angular variation. It can be seen from the results summarized below that a considerable amount of data is now available for calculations on the copper–nitrogen bonding. Since the crystal size is limited to about 0·5 mm.[3], all the measurements have been made at either 1·25 cm. or 8 mm. wavelengths, and temperatures down to 20° K. have been employed to increase the sensitivity. The hyperfine splittings and g values were all measured by means of a proton resonance magnetic field meter, and good signals were obtained from coils of 2 mm. diameter, which enabled simultaneous measurement of the proton and electron resonance in all cases.

Detailed X-ray analysis is available for the metal phthalocyanines[4], and the orientation of the planar molecules with respect to the crystalline axes is known accurately. It is therefore possible to correlate all the paramagnetic resonance measurements with the actual directions of the copper–nitrogen bonds. The central structure of the copper phthalocyanine consists of a square, formed by four nitrogen atoms, with the copper atom at the centre, coplanar with the rest of the molecule. There are two molecules per unit cell, and hence two spectra are usually observed. The magnetic field was rotated around the crystal, in the '*ab*', '*bc*' and '*ca*' planes, and then in, and perpendicular to, the plane of the molecules.

The diluted crystals show four hyperfine components, due to the $I = \frac{3}{2}$ of ^{63}Cu and ^{65}Cu. With present sensitivity the line-width cannot be reduced much below 50 gauss, and so far no fine structure, due to any covalent linkage with the nitrogen atoms, has been observed. The maximum splitting between successive hyperfine components is 210 ± 10 gauss, and the maximum g value is $2{\cdot}165 \pm 0{\cdot}004$, both occurring along the axis through the copper atom normal to the plane of the four nitrogens. In the plane perpendicular to this axis, that is, the plane of the molecule, the g-value remains isotropic at $2{\cdot}045 \pm 0{\cdot}003$. The hyperfine splitting in this plane collapses to an ill-resolved pattern, as is usual in copper salts, having an approximate value of $B = 30 \pm 10$ gauss. However, there does seem to be a 180° variation of this splitting for rotation in the plane of the molecule. The difference is small but appears to be outside the experimental error, and is being studied more closely, as it may give information which differentiates the individual copper–nitrogen bonds.

The same g values and hyperfine splittings are obtained at both 1·25 cm. and 8 mm. wave-lengths, and also over a temperature-range of 20°–290° K. They can be summarized in terms of the normal spin Hamiltonian coefficients as :

$$g_{\parallel} = 2{\cdot}165 \pm 0{\cdot}004; \quad g_{\perp} = 2{\cdot}045 \pm 0{\cdot}003$$
$$A = 0{\cdot}0208 \pm 0{\cdot}001 \text{ cm.}^{-1}; \quad B = 0{\cdot}0031 \pm 0{\cdot}001 \text{ cm.}^{-1}$$

The quadrupole interaction coefficient, Q, has not been calculated yet, as more sensitive apparatus is being constructed to allow greater dilution and better resolution. It is then hoped to carry out a detailed study of the hyperfine splitting in the molecular plane, and also search for any interaction of the electrons with the nitrogen nuclei.

This work forms part of a general programme for studying phthalocyanine, hæmoglobin and chlorophyll derivatives by paramagnetic resonance. We would like to thank the Royal Society for a grant towards the cost of the apparatus, Imperial Chemical Industries, Ltd., and Dr. C. E. Dent for supplying phthalocyanines, Dr. Stevens for much helpful discussion, and the Department of Scientific and Industrial Research for a maintenance grant (J. E. B.).

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Fixation in Electron Microscopy

Many specimens for electron microscopical examination are in the form of suspensions in salt solution. These are commonly dried on the specimen support film, and the unwanted salt crystals are removed by washing, with resultant uncertainties due to loss of material during the process, which losses may well be selective. The salts are sometimes first removed from the suspensions by dialysis; but this may lead to changes in aggregation, or to loss by precipitation before the material can be finally laid down.

These difficulties have been largely overcome here by working on a micro scale and using the mounting film itself as the dialysis membrane. The film is floated off a glass support on to a water surface in the usual way, and a single drop (or sometimes a spray of micro-drops) is placed on top of the film. The salts diffuse through the film very rapidly as it is usually only 300 A. thick, and the specimen is then mounted in the normal manner.

Further, it is often desirable to fix such specimens without change of electrolyte balance in the process. This is now readily achieved by placing drops of the suspension on a mounting film floating on a bath of the suspending medium, which contains the fixative in addition to the normal concentration of salts. Fixation proceeds gradually by diffusion of the agent through the film and the bottom of the drops, or in the vapour phase through the top of the drops, without change in electrolyte balance. Removal of unused fixative and unwanted salts is accomplished by transferring the film to a water surface as before. The concentration of the fixative gradually rises in the drops from zero to that of the main bath. Such progressive fixation has been shown to be most desirable, and the dangers inherent in adding concentrated fixative to the suspension itself are avoided.

Similarly, other micro-chemical modifications of the specimen material may be carried out without fear of selective loss by precipitation and consequent rejection prior to normal mounting procedures, since the insoluble contents of the original drops necessarily remain on the mounting film.

The method has been used to advantage over the past two years in studies of tumour and normal tissue extracts, isolated cell components (lipid fraction, mitochondria, microsomes), bacteriophage behaviour at various *p*H-levels (precisely controlled by working with standard buffer solutions) and the organisms of pleuro-pneumonia and related materials.

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Allotropes of Tungsten

The element tungsten has been observed to exist in two structural forms : the commonly encountered modification, which is body-centred cubic with $a = 3{\cdot}16$ A., and another which has a more complex cubic structure with 21 atoms per unit cell and $a = 5{\cdot}04$ A. These forms have been designated α and β respectively by Hartmann, Ebert and Bretschneider[1], who first reported the existence of the β-form, and this nomenclature is commonly accepted, although Neuberger[2] reverses the designations.

Hartmann and others have shown that the β-form is stable below *c.* 650° C., above which temperature it is irreversibly converted to α-tungsten, the transition being relatively sluggish. No reports have yet been published that α-tungsten can be reconverted to β-tungsten by purely physical processes, so that it has only been obtained hitherto by winning the element at temperatures below the transition temperature. Metallic tungsten prepared at these tem-

peratures is, however, only obtained in the β-form by the decomposition of certain of its compounds.

In this laboratory, tungsten has been prepared by several different methods and the product has been examined by X-ray diffraction. The results obtained are tabulated below, together with others taken from the literature.

Method of preparation	Temperature (° C.)	β-Tungsten present
Hydrogen reduction of β-oxide ($W_{20}O_{58}$)	465–720	+
Hydrogen reduction of γ-oxide ($W_{18}O_{49}$)	470–660	+
Hydrogen reduction of δ-oxide (WO_2)	550–590	−
Hydrogen reduction of WCl_6 vapour	*c.* 430	−
Hydrogen reduction of $WOCl_4$ vapour	*c.* 430	−
Electrolysis of fused melts containing tungstates or WO_3	600	+
Electrolysis of fused melts free from oxides	450–550	−
By an oxidation reduction cycle*	600	+
	700	−
Electrolysis of phosphate containing WO_3 (ref. 1)	600–750	+
Electrolysis of tungstates (ref. 3)	500	+
Hydrogen reduction of WO_3 (ref. 4)	up to 800	+
Films of tungsten developed on the envelopes of lamps (ref. 4)	—	+
Sputtered films (ref. 5)	—	+
On tungsten electrodes of spark gap (ref. 5)	—	+

* The oxidation-reduction cycle involves the transfer of metal from a tungsten filament, held at *c.* 2,000° C. in wet hydrogen, on to a nearby surface which was maintained at the temperature given in the table.

It should be noted that β-tungsten may be detected in metal formed at temperatures above the transition temperature, and this fact confirms the slowness of the β–α conversion.

We conclude that β-tungsten can only be formed by chemical processes, and then only when certain oxides are present or likely to be formed in the system. Our findings, and evidence from other work in this laboratory, appear to offer additional support for the proposal by Hägg and Schönberg[6] that the β-form is, in reality, an oxide of tungsten. Work is continuing on this subject, and we hope to publish a more complete report later.

We wish to thank Mr. M. G. Harwood, who was responsible for the X-ray diffraction examination of samples, and Mr. J. A. M. van Moll and the directors of Philips Electrical, Ltd., for permission to publish these results.

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Fine Structure of Solar Radio Transients

The impending rise of solar activity makes it appropriate to discuss some observations which have been only reported upon orally[1] and mentioned in the popular press[2]. At 480, 160 and 51 Mc./s. a study was made of progressive disturbances in the solar atmosphere[3] using high-speed recordings with fast instruments. Solar bursts were found to be composed of a great number of small transients or discrete pips. Each pip had a steep but not impulsive rise, an approximately half-sinusoidal top, at first a rapid decay and a quasi-logarithmic tail. Its duration was taken as the elapsed time, to the nearest tenth of a second, between points at 0·707 of maximum amplitude. Plots were made of duration versus amplitude which turned out to be scatter diagrams. Ninety per cent of the durations fell between two-thirds and three halves of the median, and were independent of amplitude throughout a range of more than one to a hundred. These limits represent the smallest pips observed on a quiet day and the largest separate pips during an outburst. The median durations were respectively 0·7, 2 and 6 sec. Thus the duration of a pip in seconds is approximately equal to its observed wave-length in metres, or $T = \lambda$. Obviously the many overlapping pips in a solar burst are the result of many discrete sources acting independently. Periods of high-variable background are merely a great number of pips of nearly the same amplitude and random timing.

No correlation could be found between any of the fine structure at 160 and 205 Mc./s., so the bandwidth of a pip must be much narrower. At 156 and 160 Mc./s. large pips on one trace could always be found in counterpart on the other trace. About one in a hundred of the large pips had amplitudes equal within 2 per cent. Approximately one-fifth had amplitudes equal within 10 per cent. As weaker pips were considered, the correlation became poorer. Small wiggles were entirely random and probably represent the spectral tails of pips at far-removed frequencies. Obviously the spectral width of a pip is only a few per cent of its mean frequency. Visual inspection indicated that the pips of medium amplitude were often of more nearly equal amplitude than the very strong pips. Thus an inverse relationship may exist between spectral-width and amplitude. The frequency of occurrence of the pips was greatest at 160 Mc./s., but the mean amplitude increased in a direct way with wave-length.

A few suitable recordings were made by Cornell on 1,420 Mc./s. which showed some small pips with durations of a couple of tenths of a second. Published data[4] at 19 Mc./s. show pips about a quarter of a minute long. During the greatest sunspots of 1946 and 1947, surges with durations from a half to one minute were observed[5] down to 6·7 Mc./s. All these observations provide evidence that the relation $T = \lambda$ holds approximately over a range of several hundred to one in wave-length. Some of the low-frequency data[6] confirm that the spectral width is small, such as November 18, 1948, 0135 G.M.T., peak noise 8,330 kc./s., limited to 8,270–8,400 kc./s.

Apparently, there is a fundamental relation between the mode of generation of these transients, the location of the source in the solar atmosphere and the duration of a pip. These observations were made by me during 1948–50 while associated with the National Bureau of Standards.

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Preparation of Dry Nitrocellulose Membranes and Nitrocellulose Particles

'GRADOCOL' membranes of pore diameter less than 400 mμ change their characteristics when normally allowed to dry in air. These changes, which are irreversible, include a decrease in thickness and pore diameter when the membranes are re-equilibrated in water (Table 1). Membranes dried in this way and stored in the dark in contact with one another in a weighing bottle 2 in. diam. × 3 in. height tend to coalesce and decompose after long periods of storage. Membranes of low porosity are not easily re-wetted with water after being dry for several days. 'Gradocol' membranes may be dried by the method outlined below and stored for long periods without impairment of their characteristics.

Collodion particles used for adsorption studies were obtained, either by the Loeb method[3] or by grinding under water in a ball-mill thin strips of those normally discarded portions of 'Gradocol' membranes prepared by the Elford technique[4]. The nitrocellulose particles prepared by the latter method were graded, when dry, by passage through a No. 100 B.S.S. sieve. They were then shaken with water in a stoppered cylinder and separated from finer particles by decantation. This process was repeated until the supernatant was clear. The collodion particles were activated by the method described by Sollner, Abrams and Carr[5].

Membranes or nitrocellulose particles treated by the method described above may be stored or transported in the dry state. The membranes may be marked with Indian ink and stored in the dark

Table 1

Before treatment					After treatment				
Thickness (mm.)	*RFW*	*SWC*	*APD* (mμ)	Bursting pressure (lb./sq. in. 8 mm.)	Thickness (mm.)	*RFW*	*SWC*	*APD* (mμ)	Bursting pressure (lb./sq. in. 8 mm.)
0·147	0·353	0·863	150	16	0·133	0·208	0·800	119	19
0·190	1·63	0·857	323	13	0·180	0·829	0·821	235	17

Table 2

Before treatment					After treatment				
Thickness (mm.)	*RFW*	*SWC*	*APD* (mμ)	Bursting pressure (lb./sq. in. 8 mm.)	Thickness (mm.)	*RFW*	*SWC*	*APD* (mμ)	Bursting pressure (lb./sq. in. 8 mm.)
0·038	0·0000347	0·296	2·5	100	0·038	0·0000416	0·300	2·8	99
0·054	0·0000797	0·470	9·6	69	0·053	0·000718	0·460	9·2	72
0·109	0·0148	0·819	31	44	0·110	0·0147	0·803	31	42
0·168	0·0891	0·869	75	34	0·167	0·0905	0·859	76	33
0·232	0·391	0·874	156	17·5	0·236	0·401	0·865	159	18
0·143	1·77	0·808	346	13·5	0·143	1·81	0·820	347	14
0·154	3·84	0·828	504	23*	0·158	3·80	0·818	504	23*
0·138	10·0	0·822	815	16*	0·137	9·97	0·824	813	16*
0·149	23·9	0·830	1,253	11*	0·151	23·0	0·810	1,250	11·5*
0·119	42·9	0·791	1,723	12*	0·121	41·7	0·782	1,700	12*
0·139	59·9	0·812	2,008	—	0·140	58·9	0·811	1,991	—

* Values for the test when disk with hole 4 mm. diam. was used. The data shown in columns 5 and 10 indicate the relative strengths of the membranes. The membrane was supported on a brass disk of thickness 2 mm. having a central circular hole of diameter 4 mm. or 8 mm. The disk with membrane surmounted by a rubber washer was placed in a special adaptor which was clamped to the top half of an Elford ultrafilter (ref. 6) by means of a hexagonal nut. Pressure was applied to the system and increased slowly until the membrane was ruptured. The minimum pressure required to break the membrane is recorded in column 5 or 10. The rate of flow of water (*RFW*), specific water content (*SWC*) and average pore diameter (*APD*) were determined by the methods described by Elford and Ferry (ref. 7)

Brown[1] has graded collodion membranes, after coagulation in water, by immersing them in mixtures of ethyl alcohol and water in varying proportions. Unsuccessful attempts were made in this laboratory to swell dried 'Gradocol' membranes by similar methods using various alcohols.

'Gradocol' membranes of porosities ranging from 3 mμ to 2,000 mμ were dried by treatment with either ethyl, *n*-propyl, *iso*propyl, *n*-butyl, *iso*butyl or amyl alcohol, followed by either chloroform, carbon tetrachloride, dichlorethylene, benzene or petroleum ether. For the whole range of porosities, only *iso*butyl or amyl alcohol could be used successfully in combination with petroleum ether (preferably of boiling point 40–60° C.) for drying the membranes without impairment to their characteristics (Table 2) (cf. Grabar[2]).

The membrane to be dried (4·0 cm. or 5·6 cm. in diameter, weighing 0·05–0·1 gm.) was placed between folds of filter paper to remove superficial water, and then immersed in 50 ml. *iso*butyl or amyl alcohol. It was transferred twice to approximately 50 ml. fresh alcohol in separate closed vessels for 5–10 min. intervals. Then the superficial alcohol was removed with filter paper and the membrane washed three times with petroleum ether in a similar manner. The membrane was dried at room temperature or 60° C. for many months in paper envelopes or glass vessels together with others of different porosity. When re-equilibrated against water, their characteristics remain unchanged from the original; that is, thickness, rate of flow of water, mechanical strength, specific water content and porosity remain unaltered (see Table 2).

Such dried membranes of predetermined characteristics may be sealed, by means of a 5 per cent solution of nitrocellulose shreds in ether : alcohol (1 : 1) mixture, to the end of a narrow tube to make a filter stick or a wide tube (for example, a Gooch crucible adaptor) for use in dialysis.

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Chromatography and Paper Electrophoresis of Sulphonphthalein Dyes

Two of the sulphonphthalein dyes, bromophenol blue[1] and bromocresol green[2], have been used widely for the detection of protein after electrophoresis on filter paper. The uptake of bromocresol green by protein under these conditions has been studied recently by Franglen and Martin[3]. Extending this work, the purity of other sulphonphthalein dyes has been investigated with paper chromatography and filter paper electrophoresis; the methods used and the results obtained are described below.

The dyes examined are listed in Tables 1 and 2, and were supplied by the British Drug Houses, Ltd., as a grade suitable for *p*H determination. These were made up as 2 per cent (w/v) solutions in absolute ethanol; all the dyes went completely into solution.

The positions of the dyes after chromatography or electrophoresis were determined by inspection under normal light, and under ultra-violet light of 2537 A. given by a Hanovia 'Chromatolite'. Under ultra-violet light, bright fluorescence was observed in all the dyes except in those containing substituted *m*-cresol rings; these, in contrast, were markedly absorbent.

For chromatographic analysis, the solutions were applied as 20-μl. spots by an 'Agla' microsyringe to sheets of Whatman's filter paper No. 3 *MM*. A number of different developing systems were tried; the following pair were found to be the most satisfactory. In the first, the paper was equilibrated over-night with purified *tert.*-amyl alcohol and concentrated ammonia solution (spec. grav. 0·880), and was developed by descending chromatography with the following mixture: purified *tert.*-amyl alcohol, 200 ml., and concentrated ammonia solution (analytical reagent grade, spec. grav. 0·880), 50 ml. The chromatogram was run for 26 hr., during which the front advanced about 31 cm. past the original positions of the spots. In the second set of conditions, the paper was equilibrated over-night with purified *tert.*-amyl alcohol, glacial acetic acid and water, and was developed with a solution containing purified *tert.*-amyl alcohol, 200 ml., glacial acetic acid (analytical reagent grade), 50 ml., and distilled water, 50 ml. The chromatogram was run for 26 hr., during which the front advanced about 34 cm. past the original positions of the spots.

The results are shown in Table 1, in which the R_F of each main component is noted, together with the number of other components detected. In most of the dyes, these other components are present in small quantities, the majority of them being detected only by their fluorescence under ultra-violet light. In the case of chlorophenol red, however, the seven other components form a large part of the sample, and four of them are clearly visible on the chromatogram under normal light. One of the components separated from the chlorophenol red sample appeared to be identical with bromophenol blue, both by chromatography in the two different developing systems described and by paper electrophoresis.

Table 1. Chromatographic Analysis of Sulphonphthalein Dyes on Whatman's No. 3 *MM* Filter Paper

Dye	Developing system			
	Amyl alcohol – ammonia		Amyl alcohol – acetic acid	
	R_F of main component	No. of other components	R_F of main component	No. of other components
Bromophenol blue	0·27	1	0·74	0
Bromocresol green	0·32	1	0·79	0
Chlorophenol red	0·09	6	0·67	6
Bromophenol red	0·11	4	0·68	5
Bromocresol purple	0·19	2	0·76	5
Bromothymol blue	0·50	0	0·88	0
Phenol red	0·06	4	0·54	3
Cresol red	0·12	4	0·67	3
Metacresol purple	0·16	3	0·66	2
Thymol blue	0·70	0	0·85	0

Table 2. Electrophoretic Analysis of Sulphonphthalein Dyes on Whatman's No. 4 Filter Paper in 0·06 *M* Diethylbarbiturate Buffer, *p*H 8·6

Dye	Mobility of main component (cm.²/V. sec. × 10⁵)	No. of other components
Bromophenol blue	12·8	0
Bromocresol green	13·5	0
Chlorophenol red	14·4	3
Bromophenol red	13·8	1
Bromocresol purple	13·4	2
Bromothymol blue	11·9	0
Phenol red	13·8	3
Cresol red	12·2	3
Metacresol purple	12·2	0
Thymol blue	9·0	0

In both chromatographic systems, all the components formed compact spots, except those of bromophenol blue and the 'bromophenol blue' spot in the chlorophenol red sample. In the latter cases, pronounced tailing occurred in the amyl alcohol – ammonia run. Earlier observations suggest that this tailing is due to a gradual and irreversible breakdown of bromophenol blue in alkaline conditions[3]. No breakdown was observed in any of the other dyes in either of the systems.

For electrophoretic analysis, the dye solutions were applied as 5-μl. spots to a sheet of Whatman's No. 4 filter paper. Electrophoresis was carried out in an apparatus similar to that described by Franglen[3], using 0·06 *M* diethylbarbiturate buffer, *p*H 8·6, and applying a potential difference of 8·0 V./cm. for 3 hr.

The results of electrophoresis are shown in Table 2. In calculating the rates of migration of the dyes, endoelectrosmosis has been taken into account. This was determined from the movement of a spot of dextran solution included in the run[4].

These analyses show that sulphonphthalein dyes can be readily distinguished from each other by filter-paper techniques. Chromatography was found to be more effective in most cases than electrophoresis; the latter method, however, enables bromophenol red to be separated from cresol red. It is also apparent from these analyses that the majority of the samples tested have appreciable quantities of impurities. This may prove to be of importance in their use for the semi-quantitative determination of *p*H.

I wish to thank Prof. N. H. Martin for his encouragement during this work, and to acknowledge the financial help given by the Research Fund of St. George's Hospital.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 17

SOCIETY OF CHEMICAL INDUSTRY (joint meeting of the AGRICULTURE and PESTICIDES GROUPS, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. J. T. Martin and Mr. E. V. Coles: "The Analysis of Insecticides—Tar Oils and Summer Oils"; Mr. K. Gardner: "The Analysis of Weedkillers—MCPA and Dinoseb".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. W. H. Arisz (University of Groningen): "Problems of Transport in Plants". (Further Lectures on January 19 and 21.)*

INSTITUTE OF METAL FINISHING (at the Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. V. F. Henley: "Some Aspects of Sulphuric Acid Anodising to Specification D.T.D. 910".

PHARMACEUTICAL SOCIETY OF GREAT BRITAIN (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Dr. Douglas McKie: "The Origins of Chemistry—Alchemy or Technology?"

Tuesday, January 18

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. J. Z. Young, F.R.S.: "The Counting of Microscopic Particles".*

INSTITUTE OF PHYSICS, ELECTRONICS GROUP (at 47 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. R. F. Saxe: "Millimicrosecond Techniques".

INSTITUTION OF CHEMICAL ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. I. R. C. Pratt and Mr. J. A. McWilliams: "Performance Data for Expanded Metal Column Packing"; Mr. F. Knelmann, Mr. N. Dombrowski and Prof. D. M. Newitt: "The Mechanism of Drop Formation from Gas or Vapour Bubbles".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Human Operator in Closed Loop Control Systems".

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. C. Bloomfield: "Leaf Leachates as a Factor in Pedogenesis".

SCIENTIFIC FILM ASSOCIATION (in the Shell Film Theatre, Shell-Mex House, Strand, London, W.C.2), at 6.30 p.m.—Mr. Trevor Fletcher: "Cinemathematics".

SOCIETY FOR ANALYTICAL CHEMISTRY, PHYSICAL METHODS GROUP at the Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1), at 6.30 p.m.—Papers on "Solvent Extraction".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. E. G. West: "Manufacture of Integral Structures".

Wednesday, January 19

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. W. Idris Jones: "Research in the Coal Industry" (Cadman Memorial Lecture).

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, South Kensington, London, S.W.7), at 5 p.m.—Discussion meeting on "Airflow Over Mountains".*

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. Philip Redfern: "Net Investment in Fixed Assets in the United Kingdom, 1938–1953".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Prof. L. S. Penrose, F.R.S.: "The Genetics of Microcythaemia (Thalassaemia)".*

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "Education and Training for Engineers and Craftsmen in France".

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the LONDON SECTION of the SOCIETY OF CHEMICAL INDUSTRY, in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 6.30 p.m.—Prof. M. Stacey, F.R.S.: "Some Recent Advances in Organic Chemistry".

Thursday, January 20

BONE AND TOOTH SOCIETY (at the Institute of Orthopædics, 234 Great Portland Street, London, W.1), at 5 p.m.—Symposium on "Fluorosis".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Miss D. J. Jackson: "The Capacity for Flight of Water Beetles, with Observations on Various Species occurring in the Western Scottish Isles"; Dr. W. A. Clark: "Plant Distribution in the Western Isles".

INSTITUTE OF FUEL (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Discussion on "The Beaver Report of the Committee on Air Pollution".*

UNIVERSITY COLLEGE, LONDON (in the Electrical Engineering Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. F. Brailsford: "The Domain Theory of Ferromagnetism". (Further Lectures on January 27 and February 3.)*

INSTITUTE OF PHYSICS, EDUCATION GROUP (at 47 Belgrave Square, London, S.W.1), at 6 p.m.—Prof. Norman Ramsey: "The Training of Physicists in the United States of America".

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (in the Lecture Hall of the Institution of Structural Engineers, 11 Upper Belgrave Street, London S.W.1), at 6 p.m.—Mr. Y. W. Rayden: "Plastics in the Building Industry".

CHEMICAL SOCIETY (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.30 p.m.—Prof. H. C. Longuet-Higgins: "The Role of the π-Electron in Aromatic Chemistry" (Tilden Lecture).

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Symposium on "Loiasis".

BRITISH INSTITUTE OF RADIOLOGY, incorporated with the RÖNTGEN SOCIETY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 7.45 p.m.—Special General Meeting, followed by Scientific Papers.

BRITISH PSYCHOLOGICAL SOCIETY, SOCIAL PSYCHOLOGY SECTION (in the Eugenics Theatre, University College, Gower Street, London, W.C.1), at 8.15 p.m.—Prof. T. H. Pear: "Etiquette, Manners and Good Will".

Friday, January 21

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (in the Great Hall of Battersea Polytechnic, Battersea Park Road, London, S.W.11), at 10 a.m.—Exhibition—"Corrosion Prevention in the Home".*

ROYAL GEOGRAPHICAL SOCIETY (joint meeting with the INSTITUTE OF NAVIGATION, at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. Frank Evans: "Transatlantic Drift".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SCIENTIFIC OFFICER, Grade I (with a university degree of high standard in physics or equivalent qualifications, and preferably with some experience in optical instrumentation), IN THE INSTRUMENTATION SECTION of the Aeronautical Research Laboratories (Department of Supply—High Speed Aerodynamics Division), Salisbury, South Australia, for the development and design of general physical and particularly optical instruments for aerodynamics research—Senior Representative (A.P.23), Department of Supply, Australia House, Strand, London, W.C.2 (January 20).

ANALYTICAL CHEMIST (with an appropriate degree or Associate of the Royal Institute of Chemistry, and preferably with some experience in an industrial laboratory) in the Central Laboratory—Chief Personnel Officer, North Western Gas Board (Liverpool Group), Radiant House, Bold Street, Liverpool 1 (January 24).

AGRONOMIST, Grade 3 (with a degree in agriculture or equivalent qualifications, and experience in agronomic research and commercial rubber planting), in the Public Service of the Territory of Papua and New Guinea—The Official Secretary, Australia House, The Strand, London, W.C.2 (January 31).

GEORGE ANGUS STUDENT (graduate of an approved university or holder of approved qualifications) for postgraduate research in the Department of either Chemistry, Physics or Mechanical Engineering—The Registrar, King's College, Newcastle-upon-Tyne (January 31).

LECTURER IN ANIMAL NUTRITION in the Department of Veterinary Hygiene and Animal Husbandry—Secretary, Royal Veterinary College, Royal College Street, London, N.W.1 (January 31).

RESEARCH OFFICER (with an honours degree in science with botany and chemistry as major subjects, or in agricultural science or equivalent qualifications) IN THE PLANTS AND SOILS LABORATORY, Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization, Brisbane, Queensland, to undertake studies on the factors limiting legume establishment in the sub-tropical areas and Southern Queensland—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 146/34 (February 5).

SENIOR LECTURER IN PHYSICS, and a LECTURER IN MATHEMATICS, at Kumasi College of Technology, Gold Coast—The Secretary, Advisory Committee on Colonial Colleges, 1 Gordon Square, London, W.C.1 (February 7).

READER IN ELECTRICAL ENGINEERING at the University of Adelaide, Adelaide, South Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Adelaide, February 14).

LECTURERS IN ENGINEERING—The Registrar, The University, Manchester 13 (February 15).

LECTURER or ASSISTANT LECTURER (with special interests in genetics or genecology) IN BOTANY—The Registrar, The University, Leeds 2 (February 19).

ASSISTANT (with a degree in agriculture or equivalent qualifications and preferably at least two years postgraduate experience) IN THE AGRICULTURAL SECTION—The Director, Tea Research Institute of East Africa, P.O. Box 91, Kericho, Kenya Colony (February 28).

HEAD (with high qualifications in geology and experience in both teaching and research) OF THE DEPARTMENT OF GEOLOGY—The Principal, Chelsea Polytechnic, Manresa Road, London, S.W.3 (February 28).

UNIVERSITY LECTURER, and UNIVERSITY DEMONSTRATORS (2) IN CHEMICAL ENGINEERING—The Appointments Committee of the Department of Chemical Engineering, Tennis Court Road, Cambridge (March 11).

RESEARCH OFFICER (with at least an honours degree in metallurgy or metallurgical engineering, or equivalent qualifications) IN THE MECHANICAL ENGINEERING RESEARCH LABORATORY, South African Council for Scientific and Industrial Research, Pretoria, for research work in the field of ferrous and non-ferrous physical metallurgy—South African Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2 (Pretoria, March 15).

I.C.I. RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY, CHEMOTHERAPY, ENGINEERING, METALLURGY, PHARMACOLOGY, PHYSICS or allied subjects—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 16).

TURNER AND NEWALL RESEARCH FELLOWS IN ENGINEERING, INORGANIC CHEMISTRY, PHYSICS or an allied subject—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 16).

AERODYNAMICISTS and AERONAUTICAL ENGINEERS, Scientific Officer grade (with a first- or second-class honours degree in engineering, physics or mathematics, and preferably with some research or experimental experience of aircraft problems) at the Ministry of Supply Aeroplane and Armament Establishment, Amesbury, Wilts; National Gas Turbine Establishment, near Farnborough, Hants; Royal Aircraft Establishment, Farnborough, Hants; and at London H.Q.—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.354/54A.

AGRICULTURAL EDUCATION OFFICER (with a degree in agriculture and experience in teaching), in Basutoland, to take administrative and academic charge of a new training centre for subordinate staff of the Agricultural Department—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.63/76/07.

ASSISTANT PROFESSOR (with a special interest in low temperature research) IN THE DEPARTMENT OF PHYSICS—Prof. W. H. Watson, University of Toronto, Toronto, Canada.

ASSOCIATE PROFESSOR OF PHYSICS—The President, Memorial University of Newfoundland, St. John's, Newfoundland, Canada.

CHEMIST, Experimental Officer grade (preferably with experience of analytical work in any field), IN THE DEPARTMENT OF INSECTICIDES AND FUNGICIDES, for general analytical work and assisting in developing analytical methods for determining insecticides in soil and in plant materials—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

CHEMIST (with a degree in natural science, and preferably post-graduate experience, particularly in soil survey work) IN THE AGRICULTURAL DEPARTMENT, Sierra Leone, to make a soil survey of part of the Northern Province of Sierra Leone, with particular reference to the nutrient status and fertilizer requirements of soils suitable for mechanized rice cultivation—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.63/15/04.

CHEMISTS (with at least H.N.C. in chemistry or equivalent qualifications) to develop and apply methods of analysing biological and other materials for very low levels of radioactivity—Establishments Officer, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 2/103/217.

EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER (with at least H.S.C. (science) or equivalent, and preferably with some experience in the handling of explosives together with some knowledge of electronics), at Fort Halstead, Kent, to perform experimental physical research using small explosive charges and high-speed recording equipment—Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 146/WGE/2.

LECTURER (with experience in wind tunnel research work) IN THE DEPARTMENT OF AERODYNAMICS—The Recorder, College of Aeronautics, Cranfield, Bletchley, Bucks.

PLANT PATHOLOGIST (graduate in pure or applied botany) IN THE HOP RESEARCH DEPARTMENT—The Registrar, Wye College, Wye, Kent.

RESEARCH ASSISTANT (preferably with previous experience in metallurgical analysis) to assist in experimental work connected with the chemistry of steel making, and to carry out analysis of metals and slags—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Analysis".

SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics or electrical engineering, or equivalent qualifications), at the R.A.F. Station, near High Wycombe, Bucks, for operational research duties, theoretical studies and development work in the field of communications and general electronics—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.109/54A.

SCIENTIFIC OFFICER (with a degree in chemistry or equivalent), at the Ministry of Agriculture and Fisheries, Tolworth, Surrey, for general chemical and analytical work connected with chemical methods for the control of various animal pests and insects on stored products—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street London, S.W.1, quoting F.679/54A.

SENIOR EXPERIMENTAL OFFICER (preferably with a pass degree in chemistry, and previous experience of the control of staff and of work on explosives), to advise technical and scientific staff on safe working in laboratories, pilot plant, and production units associated with a wide range of chemical and physical research problems—Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 336/WGE/2.

TECHNICAL ASSISTANTS (with Inter. B.Sc. or equivalent qualification) at the Central Laboratory, Chiswick—The Staff Officer (F/EV 519), London Transport, 55 Broadway, London, S.W.1.

TECHNICIAN (with a sound knowledge of routine hæmatology procedures)—The Secretary, The Laboratory, Peace Memorial Hospital, Watford, Herts.

TECHNICIAN (with experience in the main branches of histological technique and also in photomicrography) IN THE HISTOLOGY LABORATORY—The Registrar, The University, Bristol 8.

REPORTS and other PUBLICATIONS

(not included in the Monthly Books Supplement)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 925, Vol. 247 (4 November 1954): The Lift and Moment Acting on a Thick Aerofoil in Unsteady Motion. By L. C. Woods. Pp. 131–162. 10*s*. No. 296, Vol. 247 (4 November 1954): On the Decay of a Normally Distributed and Homogeneous Turbulent Velocity Field. By I. Proudman and W. H. Reid. Pp. 163–189. 8*s*. 6*d*. (London: Royal Society, 1954.) [91]

British Museum (Natural History). Economic Series No. 1: The House-Fly as a Danger to Health—Its Life History and How to Deal with It. Sixth edition. Pp. iii+17. (London: British Museum (Natural History), 1954.) 9*d*. [91]

Bulletin of the British Museum (Natural History). Entomology. Vol. 3, No. 9: The *Protoptila* Group of the Glossosomatinae (Trichoptera: Rhyacophilidae). By Martin E. Mosley. Pp. 315–346. 10*s*. Zoology. Vol. 2, No. 7: On the Polyzoan Genus *Crepidacantha* Levinsen. By David Alexander Brown. Pp. 241–263. Vol. 2, No. 8: Subdivisions of the Genus *Ptilinopus* (Aves, Columbae). By Arthur James Cain. Pp. 265–284+2 plates. 8*s*. (London: British Museum (Natural History), 1954.) [91]

Privy Council. Medical Research Council Special Report Series No. 287: Studies on the Nutritive Value of Bread and on the Effect of Variations in the Extraction Rate of Flour on the Growth of Undernourished Children. By E. M. Widdowson and R. A. McCance. Pp. viii+137+1 plate. (London: H.M. Stationery Office, 1954.) 8*s*. 6*d*. net. [91]

Society of Chemical Industry. Proceedings of the Plastics and Polymer Group. Vol. 5, 1953. Pp. iii+152. (London: Society of Chemical Industry, 1954.) 50*s*. (12*s*. 6*d*. to members of the group). [91]

Discovery Reports. Vol. 27. Pp. 219–234: The Planktonic Decapod Crustacea and Stomatopoda of the Benguela Current. Part 1: First Survey, R.R.S. *William Scoresby*, March 1950. By Dr. Marie V. Lebour. (Cambridge: At the University Press, 1954.) 6*s*. 6*d*. net. [91]

Register of Research in the Social Sciences in Progress and in Plan. No. 11: 1953–1954, with a Directory of Research Institutions. Edited by Feodora Stone. Pp. vii+168. (London: Cambridge University Press, 1954.) 25*s*. net. [91]

Agricultural Research Institute of Northern Ireland. Twenty-Seventh Annual Report, 1953–54. Pp. 38. (Hillsborough, Co. Down: Agricultural Research Institute of Northern Ireland, 1954.) [91]

Forestry in Northern Ireland. Pp. 20. (Belfast: Ministry of Agriculture, 1954.) [91]

Other Countries

United States Department of Agriculture: Forest Service. Circular No. 944: Biology and Control of the Engelmann Spruce Beetle in Colorado. By C. L. Massey and N. D. Wygant. Pp. i+35. (Washington, D.C.: Government Printing Office, 1954.) 20 cents. [91]

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 35, No. 9: Family History and Longevity. Pp. 12. (New York: Metropolitan Life Insurance Company, 1954.) [91]

Sudan Government. Wellcome Chemical Laboratories. Medical Services—Ministry of Health. Report of the Government Analyst for the period 1.7.1953–30.6.1954. Pp. 24. (Khartoum: Ministry of Health, 1954.) [91]

United States Department of Commerce: National Bureau of Standards. Circular No. 556: Thermal Conductivity of Metals and Alloys at Low Temperatures: a Review of the Literature. By Robert L. Powell and William A. Blanpied. Pp. iv+68. (Washington, D.C.: Government Printing Office, 1954.) 50 cents. [91]

Koninklijk Nederlands Meteorologisch Instituut. Mededelingen en Verhandelingen. No. 59: Tien Wetenschappelijke Bijdragen Uitgegeven bij het Honderdjarig bestaan van het K.N.M.I. (With English summaries.) Pp. ii+267–464. 12,50 florins. No. 60: Nauwkeurigheid en Betrouwbaarheid van Temperatuur- en Vochtigheidsbepalingen in Buitenlucht met Behulp van Kwikthermometers. By Dr. C. Kramer, Dr. Ir. J. J. Post en Dr. J. P. M. Woudenberg. Pp. 60+4 plates. No. 61: Some Aspects of the Influence of the Earth's Surface on the Atmosphere. By Dr. J. A. Businger. Pp. xii+78+4 florins. (Gravenhage: Staatsdrukkerij- En Uitgeverijbedrijf, 1954.) [91]

Koninklijk Nederlands Meteorologisch Instituut. Seismic Records at De Bilt. No. 37: 1949. Pp. vii+30. (Gravenhage: Staatsdrukkerij- En Uitgeverijbedrijf, 1954.) 1 florin. [91]

Transactions of the American Philosophical Society. New Series. Vol. 44, Part 5 (1954): An Early Archaeological Site near Panuco, Vera Cruz. By Richard S. MacNeish. Pp. ii+539–642. (Philadelphia: American Philosophical Society, 1954.) 2 dollars. [91]

Jahrhundertfeier der Geburtstage von Paul Ehrlich und Emil Von Behring. Ein Bildbericht von den Festlichen Tagen in Frankfurt Main, Marburg-Lahn und Hoechst am 14, 15 und 16, März, 1954. Pp. 40. (Frankfurt (M): Farbwerke Hoechst AG, vormals Meister Lucius and Brüning, 1954.) [91]

Unión Nacional de Periodistas. Alfabetización y Educación de Adultos. Decalogo: Para la Conservacion de las Tierras Agricolas. Por Dr. M. Acosta Solis. Pp. 19. (Quito, Equador: Dr. M. Acosta Solis (P.O. Box 408), 1954.) [91]

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